Canadian Agency for Drugs and Technologies in Health

RAPID RESPONSE REPORT:
SUMMARY WITH CRITICAL APPRAISAL

TITLE: Porcelain-Fused-to-Metal Crowns versus All-ceramic Crowns: A Review of the Clinical and Cost-Effectiveness

DATE: 29 May 2015

CONTEXT AND POLICY ISSUES

Porcelain-fused-to-metal (PFM) crowns have been considered the gold standard for the repair of damaged teeth.[1] PFM crowns have good mechanical properties, satisfactory esthetic results, and an acceptable biological quality needed for periodontal health.[1] However, PFM crowns have some limitations that may limit their use. For example, the esthetic of PFM crowns is limited by the metal framework and the layer of opaque porcelain needed for masking the underlying metal grayish shade. Recently the cost of precious metals has risen markedly making PFM relatively unattractive from an economic standpoint.[1]

All-ceramic crowns have been used over the last four decades as an alternative for PFM crowns to overcome their esthetic limitations. All-ceramic crowns can be made from different types of ceramic, and not all ceramic types have the same physical and esthetic proprieties. Historically, resin-based crowns were the first metal-free crowns to be used, but they were abandoned because of their low fracture resistance.[2] Newer metal-free crowns are increasingly being used in dental practice;[3] these crowns are made from different ceramic materials such as lithium disilicate, zirconia, leucite-reinforced glass, and glass-infiltrated alumina.

Policy makers require information on the relative benefits and costs associated with different types of crown materials in order to support reimbursement decisions. The objective of this review is to evaluate the clinical and cost-effectiveness of dental PFM and all-ceramic crowns.

RESEARCH QUESTIONS

1. What is the clinical evidence on the longevity of all-ceramic/porcelain crowns?

2. What is the clinical evidence on the longevity of porcelain-fused-to-metal crowns?

3. What is the clinical evidence of the longevity of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

4. What is the long-term (eight years and longer) cost-effectiveness of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

5. What are the contextual considerations for all-ceramic crowns or porcelain-fused-to-metal crowns that may affect their clinical or cost-effectiveness?

KEY FINDINGS

A total of twenty-nine systematic reviews and studies were included, the majority of these studies were based on observational uncontrolled studies. Long term survival (>8 years) of all-ceramic crowns ranged from 84% to 100%, and for porcelain-fused-to-metal crowns ranged from 92% to 96%. Comparative studies showed lower survival rate for all-ceramic crowns (48%) relative to porcelain fused to metal crowns (62%). The cost-effectiveness analysis showed that porcelain-fused-to-metal crowns become more cost-effective than all-ceramic crowns after 10 years of used. None of the identified literature provided reliable evidence about the contextual considerations that may have an influence on the clinical and cost-effectiveness. The authors of one non-randomized study analyzed factors that had an effect on the longevity of crowns, but they did not report separate analyses for different crown materials.

METHODS

Literature Search Methods

This report is based on a literature search conducted for a previous CADTH report. A limited literature search was conducted on key resources including PubMed, The Cochrane Library, University of York Centre for Reviews and Dissemination (CRD), ECRI databases, Canadian and major international health technology agencies, as well as a focused Internet search. Methodological filters were applied to a broad search of any type of dental crown to limit retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies and economic studies. No filters were applied to a narrower search of articles comparing all-ceramic to metal-ceramic dental crowns. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2000 and April 17, 2015.

Rapid Response reports are organized so that the evidence for each research question is presented separately.

Selection Criteria and Methods

One reviewer screened citations and selected studies. In the first level of screening, titles and abstracts were reviewed and potentially relevant articles were retrieved and assessed for inclusion. The final selection of full-text articles was based on the inclusion criteria presented in Table 1.

Table 1: Selection Criteria	
Population	Any individual requiring a crown
Intervention	Porcelain-fused-to-metal crowns All-ceramic dental crowns (including reinforced all-ceramic/porcelain dental crowns such as, but not limited to, alumina, zirconia, e.max, or CEREC crowns)
Comparator	No comparator Comparisons between crown types
Outcomes	Clinical effectiveness (e.g. longevity of crown, failure rates, wear of crowns or teeth, crown survival at 5/10/15 years post-insertion) Cost-effectiveness (long term: eight years or longer) Contextual considerations
Study Designs	Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies, economic evaluations.

Exclusion Criteria

Articles were excluded if they did not meet the selection criteria outlined in Table 1, they were duplicate publications or already included in one of the included systematic reviews. Studies were also excluded if they were case series, commentary, reviews, laboratory studies, and surveys. Studies evaluating crowns supported by implants or multiple-unit crowns were excluded. Implant-supported crowns were excluded because their abutments are not prepared by dentists in the dental clinics; instead, they are usually provided by implant's manufacturers or fabricated in dental laboratories. Therefore, including implant-supported crowns in this review would have masked a major confounding factor related to the effect of dentist skills and experience on all-ceramic crown survival. Studies that evaluated esthetics without reporting crown survival or longevity were also excluded.

Critical Appraisal of Individual Studies

The included systematic reviews were critically appraised using AMSTAR tool.[4] Downs and Black checklist was used to evaluate randomized and non-randomized,[5] economic studies were assessed using the Drummond checklist.[1] Summary scores were not calculated for the included studies; rather, a review of the strengths and limitations of each included study were described.

SUMMARY OF EVIDENCE

Quantity of Research Available

A total of 1671 citations were identified in the literature search. Following screening of titles and abstracts, 1522 citations were excluded and 149 potentially relevant reports from the electronic search were retrieved for full-text review. Three potentially relevant publications were retrieved from the grey literature search. Of these potentially relevant articles, 123 publications were excluded for various reasons, while 29 publications met the inclusion criteria and were included in this report. Twenty-two studies provided answers to the first question about the longevity of all-ceramic crowns, two studies provided answers to the second question about the longevity of metal-ceramic crowns, four studies provided information about the comparative longevity of all-ceramic and metal-ceramic crowns, and one study provided cost evaluation. One of the

comparative studies provided partial information about some contextual factors affecting crown survival. Appendix 1 describes the PRISMA flowchart of the study selection.

Appendix 5 presents a list studies that were already included in at least one of the included systematic reviews.

Summary of Study Characteristics

A summary of individual study characteristics is presented in Appendix 2.

What is the clinical evidence on the longevity of all-ceramic/porcelain crowns?

A total of ten systematic reviews,[6-15] one RCT,[16] and eleven non-randomized uncontrolled studies provided answers to this question (see Table 2 and Table 3).[17-27]

The ten systematic reviews included more than 60 unique primary studies; some of which were included in more than one systematic review (Table 2). All except four primary studies were observational uncontrolled studies published in the period between 1992 and 2013. The total number of crowns included the systematic reviews ranged from 12 crowns in Larsson et al.[7] to 696 crowns in Pieger et al.[6] The majority of the included primary studies had short-term follow-up below five years; one systematic review by Pieger et al.[6] included a study with 10-year follow. Authors of all systematic reviews did not report from where patients were recruited, and they did not systematically report information on tooth vitality or the presence of post and core for endodontically treated teeth.

The included systematic reviews varied in terms of the evaluated all-ceramic material. Some of them evaluated one specific all-ceramic crown material; for example, Pieger et al.[6] evaluated lithium disilicate crowns only, Larsson et al.[7] evaluated zirconia-based crowns, while Heintze et al.[9] and El-Mowafy et al.[13] evaluated leucite-reinforced ceramic (IPS Empress). On the other hand Wang et al.[8] Kassem et al.,[10] Wittneben et al.,[11] Wassermann et al.,[12] and Ho et al.[14] were not specific to the crown material and included different all-ceramic crown materials.

All included systematic review evaluated the longevity of all-ceramic crowns; however, they varied in their definition of success and failure. They also differed in reporting of the results; some of them simply reported the survival rate at the end of follow-up such as Heintze et al. 2010,[9] Kassem et al. 2010,[10] El-Mowafy et al. 2002,[13] Ho et al. 2012.[14] The remaining systematic reviews were more thorough and reported the cumulative survival rate which takes into account the time each crown was exposed to the risk of failure.

Rammelsberg et al.[16] published the only randomized-controlled trial that evaluated longevity of all-ceramic crowns (Table 3). The trial tested the effect of preparation finishing line (chamfer versus shoulder finish lines) on the survival of metal free polymer crowns (Artglass). The authors included 71 patients and 117 single crowns in the trial, and followed patients for three years. During this period the authors counted crown failures, which was defined as fractures or decementation.

Five prospective uncontrolled studies provided information about the longevity of all-ceramic crowns (Table 3).[17-21] Three studies recruited patients from a university-based practice,[17,19,20] while the other two studies had patients from private dental practices.[18,21] These were relatively small studies with a sample size ranging from 34 patients (41 crowns)[20] to 50 patients (155

crowns).[19] Ceramic material varied in these studies; two studies evaluated lithium disilicate all-ceramic crowns,[17,20] and the remaining three studies evaluated one material each: zirconia-based crowns,[18] densely sintered aluminum oxide,[19] and leucite glass-ceramic.[21] The main outcome in these studies was cumulative survival rate at two[20,21] to nine years.[17,19]

The remaining six studies were retrospective uncontrolled studies (Table 3).[22-27] These studies were conducted in Europe[22,24,25,27,28] and the USA[26] between the 2013 and 2015. Three studies were based on data collected from private dental practices,[22,24,27] two were based on university-based patient data,[25,26] and one study had a mixed population of university and private practices.[23] The sample size ranged from 88 single crowns (from 70 patients)[24] to 618 crowns (from 148 patients).[23] Two studies evaluated lithium disilicate all-ceramic crowns,[22,25] two studies evaluated zirconia-based crowns,[23,24] and the last two studies had both zirconia- and alumina-based crowns.[26,27] The authors of these studies used cumulative survival rates as the primary outcome.

What is the clinical evidence on the longevity of porcelain-fused-to-metal crowns?

Two uncontrolled studies provided information about the longevity of porcelain-fused-to-metal crowns (Table 4).[29,30] Both studies were conducted in university-based settings in Germany. The prospective study by Hey et al.[30] included 21 patients and 41 crowns, while the retrospective study by Behr et al.[29] was based on the records of 997 crowns treated between 1984 and 2009.[29] Hey et al. were interested in the longevity of crowns made with titanium coping using computer-aided design/computer-aided manufacturing (CAD/CAM) technology.[30] Whereas Behr at al. evaluated the longevity of crowns that had precious-metal cores.[29] Hey et al. followed-up the patients for six years,[30] while Behr et al. used patients data that had a follow-up up to 14 years (median 4.3 years).[29]

What is the clinical evidence of the longevity of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

Two systematic reviews,[2,31] one randomized controlled trial,[32] and one non-randomized-controlled study provided information about the comparative longevity of porcelain-fused-to-metal and all-ceramic crowns (Table 5 and Table 6).[33]

The systematic review by Sailer et al.[2] included 67 primary studies published between 1991 and 2013 (Table 5). The majority (63 out of 67) of the included primary studies were uncontrolled studies, and four of them were randomized-controlled trials. Only one randomized controlled trial compared porcelain-fused-to-metal and all-ceramic crowns; the remaining three randomized trials compared different types of either all-ceramic crowns or metal-ceramic crowns. The included studies evaluated different types of all-ceramic crowns; these were densely sintered zirconia (9 studies); densely sintered alumina (8 studies); glass-infiltrated alumina (15 studies); leucite/lithium disilicate reinforced glass ceramics (12 studies), and feldspathic/silica-based ceramic (10 studies). The remaining studies evaluated metal-ceramic crowns (12 studies), and one study included both types of crowns. The included studies were either based on private practice (20 studies) or university-based practice (47 studies), and they included from 10 to 456 patients with a total of 14,156 single crowns and a mean follow-up of 5.8 years. The main outcome was the cumulative survival rate at 5 years.

A total of nineteen primary studies were included in the systematic review by Takeichi et al.[31] six of which were also included in Sailer's review (Table 5). The included studies were published

between 1993 and 2011; four studies evaluated all-ceramic crowns, and 15 studies evaluated metal-ceramic crowns.[31] The authors did not provide information about the setting from which patients were included, and they did not report the design of each included study. The authors were interested in comparing all-ceramic crowns (zirconia-based crowns) with metal-ceramic crowns. They included a total of 3621 crowns in their analyses of annual failure rate during 24 to 39 months of observation.

Ohlmann et al. conducted a randomized-controlled trial to compare the clinical performance of posterior, metal-free polymer with metal–ceramic crowns (Table 6).[32] A total of 66 patients and 120 teeth were randomized to receive one of three crown types: polymer composite resin with a glass–fibre framework (40 crowns), polymer composite resin without a glass–fibre framework (40 crowns), and metal-ceramic crowns (40 crowns). Patients were recruited from a university setting, and they were followed for up to six years.

Burke et al. conducted a database study and compared the survival rates of different types of crowns (Table 6).[33] Data were obtained from the National Health Service (NHS) General Dental Services (GDS) in England and Wales, and it included the records of 88,000 patients and 47,474 crown restorations installed between 1990 and 2002. The authors grouped crown types into four categories: metal-crowns (7,817), porcelain jacket or all-ceramic crowns (1,434), porcelain-fused to-metal crowns (38,166), and synthetic resin full crowns (57).

What is the long-term (eight years and longer) cost-effectiveness of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

Kelly et al.[34] evaluated and compared the cost-effectiveness of alternative methods for restoring large tooth substance loss in adults (Table 7). PFM crowns and all-ceramic (porcelain jacket) crowns were included in the compared methods; Class I amalgam restorations were used as a reference for the comparison between the other methods. The analysis was based on patients' record data with all restorations performed before 1985 and followed-up for at least 10 years. The study assumed that crown removal due to endodontic or periodontal diseases was not related to crown type; therefore, the study excluded these crowns from the survival analyses. The authors considered the mean costs of restoration placement in South Australian metropolitan in 1992; the costs were obtained from Australian Dental Association fee survey in 1992.

What are the contextual considerations for all-ceramic crowns or porcelain-fused-to-metal crowns that may affect their clinical or cost-effectiveness?

The study by Burke et al. was described above, and it provided partial information about some contextual considerations of interest (Table 6).[33] The authors evaluated the influence of forty clinical factors on crown survival.

Summary of Critical Appraisal

A summary of the critical appraisal of individual studies is presented in Appendix 3.

What is the clinical evidence on the longevity of all-ceramic/porcelain crowns?

The ten reviewed systematic reviews had some shared strengths and limitations (Table 8). In seven systematic reviews, for example, the literature search was conducted by several

investigators who used more than one database and clear inclusion criteria.[6-9,11,12,14,15] The three remaining systematic reviews used one database without any hand search or grey literature screening.[9,10,13] The quality of the included studies was evaluated in two systematic reviews only.[14,15] Furthermore, all the included systematic reviews were based mainly on observational uncontrolled studies, and the authors of these reviews did not evaluate or discuss the potential selective reporting of the most successful cases. Selective reporting could be evaluated through the rate of missing information and the rate of patients who were lost to follow-up. The authors of five systematic reviews had acceptable survival analyses methods; these methods accounted for the time crowns were exposed to the risk of failure.[6-8,11,12] The remaining reviews either reported the numbers or crude rates of failure crowns. This kind of reporting does not provide an accurate survival estimates because it does not account for the time of failure and the time during which each crown was exposed to the risk of failure.

Rammelsberg et al.[16] conducted the only randomized controlled trial to answer this question. The authors managed to follow-up all included patients, but they did not report where these patients were recruited from or the inclusion criteria. In this study, the authors used appropriate survival analyses, but it was not clear if they used a statistical power calculation to determine the sample size. Blinding was not possible in this trial which might lead to differential treatment and outcome assessment.

The external validity (generalizability) was questionable in almost all the eleven uncontrolled studies. For instance, five studies included patients from private dental practices;[18,21,22,24,27] the issue with such studies is that they rely on the training and expertise of individual dentists which may not apply to other dentists. In some studies, the authors failed to report the inclusion criteria.[17,19-22,27] The survival analyses of all these studies accounted for time at risk for each crown; in one study however, the authors failed to apply imputation or censoring methods for missing data.[18]

What is the clinical evidence on the longevity of porcelain-fused-to-metal crowns?

Hey et al.[30] and Behr et al.[29] applied acceptable statistical analyses to account for time at risk and survival time of the evaluated crowns (Table 9). Hey et al. however, did not apply any imputation method to account for the patients lost to follow-up; instead, the authors excluded them for the analyses. A better approach could be including these patients in the survival analysis and censoring them at the time they stopped to show up for the follow-up visits. Furthermore, Hey et al. did not report specific inclusion criteria, and therefore, the external validity of their study could not be evaluated. The external validity of Behr's study might be limited due to the fact that the authors included patients who were treated since 1984; materials and techniques used in the earlier period of the study might not be representative to materials used more recently.

What is the clinical evidence of the longevity of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

Sailer et al.[2] used an acceptable literature search strategy (multiple investigators screening several databases and using clear inclusion criteria) (Table 10). Takeichi et al., in contrast, used one database, and they did not complement it with grey literature search.[31] Both reviews used acceptable survival analyses methods that account for time at risk, but Takeichi et al. estimated the survival rates for each type of crowns separately without conducting any comparison between the two estimates.

Ohlmann et al.[32] recruited patients from a university setting, and patients were treated by several dentists (Table 10). The benefit of such studies is that they provide a better generalizability and external validity than single dentist-based studies. The authors used a statistical power calculation to estimate the sample size. However, the authors did not report the method of randomization or how randomization was concealed. On the statistical analysis plan, the authors excluded 9/120 teeth from analysis because patients did not keep regular appointments, and was not clear how these exclusions affected the statistical power of the trial. However, it would have been more appropriate if these patients were included in the analysis and were censored at their last known status. Furthermore, authors used one of the tested interventions (polymer composite resin with glass–fibre framework) as a reference for the other interventions, and it would be more appropriate to consider metal-ceramic as the reference. The impact of this analysis was the absence of direct testing of the relative efficacy of metal-ceramic versus polymer composite resin without glass–fibre framework.

Burke et al.[33] randomly selected patients' records from a comprehensive database (National Health Service- General Dental Services in England and Wales) (Table 10). The authors used appropriate statistical analysis to estimate crown survival. However, the findings of this study might not be generalizable because the database included crowns made before 2002. Therefore, newer ceramic materials might not be available or familiar to investigators during the evaluation period used by this study.

What is the long-term (eight years and longer) cost-effectiveness of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

The economic evaluation by Kelly et al. did not report a clear definition for survival (**Table 11**).[34] Furthermore, the provision of porcelain-fused-to-metal or all-ceramic crowns was not randomized in this study; the decision to use a specific crown type may be based on patient preference, cost, criteria set by the funding agency, or other factors which may have an impact on the performance of the crown (e.g., the remaining tooth structure). The authors included restorations performed before 1985; dental materials used in these crowns fabrication were changed considerably since the installation of these crowns. This may affect the generalizability of the study results.

Summary of Findings

A summary of individual study findings is presented in Appendix 4.

What is the clinical evidence on the longevity of all-ceramic/porcelain crowns?

Short-term survival (less than five years)

Twelve studies provided short-term survival data and reported all-ceramic crown survival rates ranging from 69.8%[24] and 100% (Table 12).[6] The survival rates varied between each type of ceramic and from one study to another for the same type of ceramic. For example, the survival rate for lithium disilicate crowns ranged from 92%[13] to 99.4%.[6] Wassermann et al. reported survival rates ranging from 91.7% to 100% for In-Ceram Spinell ($MgAl_2O_4$) crowns and 92.7% to 100% for the In-Ceram Alumina (Al_2O_3) crowns.[12] The survival rates for zirconia-based crowns ranged from 69.8%[24] to 95.1%.[26] One study reported a 96% survival rate of polymer crowns.[16]

Mid-term survival (five years to eight years)

The overall mid-term survival ranged from 87.1%[10] to 98.1% (Table 12).[23] One study reported a mid-term survival of 97.9% for lithium disilicate crowns.[6] Kassem et al. reported a survival rate of 94.6% for In-Ceram crowns.[10] Zirconia-based crowns had survival rates that ranged from 89.9%[10] to 98.1%.[23]

Long-term survival (eight years or more)

Five studies reported long-term survival for all-ceramic crowns (Table 12). Three studies reported survival rates for lithium disilicate crowns that ranged from 87.4%[17] to 100%.[22] Alumina crowns had a survival rate 83.9% in one study,[19] and another study reported a survival rate of 92.8% for zirconia-based crowns.

What is the clinical evidence on the longevity of porcelain-fused-to-metal crowns?

Mid-term survival (five years to eight years)

Behr et al. reported a mid-term survival rate of 96.4% and 97.5% for anterior and posterior porcelain-fused-to-metal crown,[29] while Hey et al. reported a survival rate of 67.8% (Table 13).[30]

Long-term survival (eight years or more)

Behr et al. reported a survival rate of 92.3% and 95.9% for anterior and posterior porcelain-fused-to-metal crowns (Table 13).[29]

What is the clinical evidence of the longevity of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

Short-term survival (less than five years)

Three studies reported short-term survival rates for both all-ceramic and porcelain-fused-to-metal crowns (Table 14).[31-33] Takeichi et al. reported survival rates of 95.9% for zirconia-based crowns and 95.4% for porcelain-fused-to-metal crowns.[31] Burke et al. reported survival rates of 92% for all-ceramic crowns and 93% for porcelain-fused-to-metal crowns.[33] Ohlmann et al. reported the only statistical comparison between porcelain-fused-to-metal crowns and all-ceramic crowns.[32] The authors reported a hazard ratio of failure of 0.74 [95% confidence interval 0.29 to 1.87] for porcelain-fused-to-metal crowns relative to polymer crowns with glass-fiber framework. The hazard ratio showed that porcelain-fused-to-metal crowns had numerically lower failure rate, but the difference did not reach statistical significance.[32]

Mid-term survival (five years to eight years)

Sailer et al. reported a mid-term survival rate for porcelain-fused-to-metal crowns of 96% (Table 14).[31] The authors also reported the survival rates for several all-ceramic crown types; these were feldspathic/silica-based ceramic (90.7%), leucite or lithium-disilicate reinforced glass ceramic (96.6%), glass-infiltrated ceramic (94.6%), densely sintered alumina (96%), densely sintered zirconia (92%), and composite crowns (83.4%).[31] Burke et al.[33] reported lower survival rates for both porcelain-fused-to-metal crowns (76%) and all-ceramic crowns (68%).[33]

Long-term survival (eight years or more)

Burke et al. reported a long-term survival rate of 62% for porcelain-fused-to-metal crowns and 48% for all-ceramic crowns (Table 14).[33]

What is the long-term (eight years and longer) cost-effectiveness of porcelain-fused-to-metal crowns compared with all-ceramic crowns?

Kelly et al.[34] reported that the cost-effectiveness values at 5 and 10 years of all-ceramic (porcelain jacket) crowns relative to Class I amalgam were higher than those of PFM crowns relative to Class I amalgam (Table 15). However, this relationship was reversed at the 15 year evaluation, and PFM crowns were more cost-effective than porcelain jacket crowns due to their increased failure rates beyond 15 years. Interpretation of these finding should be in light of the fact that there were a limited number of porcelain jacket crowns (18) compared to PFM crowns (212).

What are the contextual considerations for all-ceramic crowns or porcelain-fused-to-metal crowns that may affect their clinical or cost-effectiveness?

Burke et al. used Cox-regression modelling to test the statistical significance of forty clinical factors that have a potential effect on crown survival.[33] The authors reported that the following twenty-two factors had a statistically significant influence on crown survival:

- Mean annual fees for patient
- Use of a core and post
- Pin or screw retention
- Median attendance interval for patient (days)
- Change of dentist after crown placement
- Charge-paying status
- Associated periodontal treatment
- Type of crown
- Tooth position
- Associated radiographs
- Patient gender
- Patient age group
- Mouth quadrant
- Region
- Dentist gender
- Associated examination
- Associated resin composite restoration
- Associated amalgam restoration
- Dentist country of qualification
- Associated bridgework
- Associated inlay
- Age of dentist

The authors of this study did not report separate analyses for different crown materials, so it is unclear whether these factors may influence the survival of porcelain fused to metal or all-ceramic crowns differently.

Limitations

The majority of the included studies were non-randomized studies; the decision to use a specific crown type may be based on patient preference, cost, criteria set by the funding agency, or other clinical factors which may have an impact on the performance of the crown (e.g., the remaining tooth structure). Furthermore, a very limited number of direct comparative studies was identified, and comparisons across studies might not be appropriate because of differences in patient populations, dentist skills, and variations in the availability of different restorative materials. Another limitation factor was the heterogeneity in defining crown failure across studies.

The cost-effectiveness study was based on Australian prices of dental restorations in 1992; the current review did not attempt the adjustment for currency change of inflation rates since 1992. Therefore, these prices might not be representative to the Canada prices of dental restorations in 2013.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

This review reported the survival rates of porcelain fused to metal crowns and all-ceramic crowns. The clinical performance and the cost-effectiveness of the two types of crowns were also reviewed. A total of twenty-nine systematic reviews and studies were included in the review.

With respect to the long-term survival (> 8 years) of all-ceramic crowns, data showed that survival rate varied from one study to another and from one type of ceramic to another; variation ranged from 83.9% and 100%. The long-term survival of porcelain fused to metal crowns ranged from 92.3% to 95.9%. Comparative data showed lower survival rate for all-ceramic crowns (48%) relative to porcelain fused to metal crowns (62%).

The cost-effectiveness analysis showed that all-ceramic (porcelain jacket) crowns were more cost-effective than PFM crowns until 10 years of the restoration life; after this time, PFM crowns become more cost-effective. However, these findings might not be generalizable to the currently used all-ceramic crowns because the study was based on restorations fabricated before 1985.

No conclusions regarding contextual considerations can be presented due to the lack of information that presented evidence specific to the type of crown material. One study analyzed factors that influence the longevity of all crowns placed during the study period (including all metal crowns). Some of these factors include tooth position, with shorter survival observed for crowns placed on maxillary teeth; dentist age, with longer survival observed with crowns placed by older dentists; and patient age, with shorter crown survival observed for older patients. The authors of this study did not report separate analyses for different crown materials, so it is unclear whether these factors may influence the survival of porcelain fused to metal or all-ceramic crowns differently.

PREPARED BY:
Canadian Agency for Drugs and Technologies in Health
Tel: 1-866-898-8439
www.cadth.ca

REFERENCES

1. Zarone F, Russo S, Sorrentino R. From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. Dent Mater. 2011 Jan;27(1):83-96.

2. Sailer I, Makarov NA, Thoma DS, Zwahlen M, Pjetursson BE. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part I: Single crowns (SCs). Dent Mater. 2015 Apr 1.

3. Giordano R. A comparison of all-ceramic restorative systems: Part 2. Gen Dent. 2000 Jan;48(1):38-5.

4. Shea BJ, Grimshaw JM, Wells GA, Boers M, Andersson N, Hamel C, et al. Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. BMC Med Res Methodol [Internet]. 2007 [cited 2015 May 29];7:10. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1810543/pdf/1471-2288-7-10.pdf

5. Downs SH, Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. J Epidemiol Community Health [Internet]. 1998 Jun [cited 2015 May 29];52(6):377-84. Available from: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1756728/pdf/v052p00377.pdf

6. Pieger S, Salman A, Bidra AS. Clinical outcomes of lithium disilicate single crowns and partial fixed dental prostheses: a systematic review. J Prosthet Dent. 2014 Jul;112(1):22-30.

7. Larsson C, Wennerberg A. The clinical success of zirconia-based crowns: a systematic review. Int J Prosthodont. 2014 Jan;27(1):33-43.

8. Wang X, Fan D, Swain MV, Zhao K. A systematic review of all-ceramic crowns: clinical fracture rates in relation to restored tooth type. Int J Prosthodont. 2012 Sep;25(5):441-50.

9. Heintze SD, Rousson V. Fracture rates of IPS Empress all-ceramic crowns--a systematic review. Int J Prosthodont. 2010 Mar;23(2):129-33.

10. Kassem AS, Atta O, El-Mowafy O. Survival rates of porcelain molar crowns-an update. Int J Prosthodont. 2010 Jan;23(1):60-2.

11. Wittneben JG, Wright RF, Weber HP, Gallucci GO. A systematic review of the clinical performance of CAD/CAM single-tooth restorations. Int J Prosthodont. 2009 Sep;22(5):466-71.

12. Wassermann A, Kaiser M, Strub JR. Clinical long-term results of VITA In-Ceram Classic crowns and fixed partial dentures: A systematic literature review. Int J Prosthodont. 2006 Jul;19(4):355-63.

13. El-Mowafy O, Brochu JF. Longevity and clinical performance of IPS-Empress ceramic restorations--a literature review. J Can Dent Assoc [Internet]. 2002 Apr [cited 2015 Apr 23];68(4):233-7. Available from: http://www.cda-adc.ca/jcda/vol-68/issue-4/233.pdf

14. Ho JCK, Hu YH, Montanera L, Shigapov T, Spano S. An evidence-based review of fracture resistance of CAD/CAM composite-based crowns [Internet]. Toronto: University of Toronto, Faculty of Dentistry; 2015. [cited 2015 Apr 23]. Available from: http://www.dentistry.utoronto.ca/system/files/group11_ebmreport2012_0.pdf

15. Alwash Z, Ali S, Hedayatian H, Hassan H, Leskauskiene S, Tehrani M, et al. The efficacy of all ceramic zirconium crown [Internet]. Toronto: University of Toronto, Faculty of Dentistry; 2010. [cited 2015 Apr 23]. Available from: http://www.dentistry.utoronto.ca/system/files/groupa_ebl_idapp2010_0.pdf

16. Rammelsberg P, Spiegl K, Eickemeyer G, Schmitter M. Clinical performance of metal-free polymer crowns after 3 years in service. J Dent. 2005 Jul;33(6):517-23.

17. Toman M, Toksavul S. Clinical evaluation of 121 lithium disilicate all-ceramic crowns up to 9 years. Quintessence Int. 2015 Mar;46(3):189-97.

18. Tartaglia GM, Sidoti E, Sforza C. Seven-year prospective clinical study on zirconia-based single crowns and fixed dental prostheses. Clin Oral Investig. 2014 Oct 12.

19. Galindo ML, Sendi P, Marinello CP. Estimating long-term survival of densely sintered alumina crowns: a cohort study over 10 years. J Prosthet Dent. 2011 Jul;106(1):23-8.

20. Reich S, Fischer S, Sobotta B, Klapper HU, Gozdowski S. A preliminary study on the short-term efficacy of chairside computer-aided design/computer-assisted manufacturing-generated posterior lithium disilicate crowns. Int J Prosthodont. 2010 May;23(3):214-6.

21. Mansour YF, Al-Omiri MK, Khader YS, Al-Wahadni A. Clinical performance of IPS-Empress 2 ceramic crowns inserted by general dental practitioners. J Contemp Dent Pract. 2008;9(4):9-16.

22. Valenti M, Valenti A. Retrospective survival analysis of 110 lithium disilicate crowns with feather-edge marginal preparation. Int J Esthet Dent. 2015;10(2):246-57.

23. Guncu MB, Cakan U, Muhtarogullari M, Canay S. Zirconia-based crowns up to 5 years in function: a retrospective clinical study and evaluation of prosthetic restorations and failures. Int J Prosthodont. 2015 Mar;28(2):152-7.

24. Gherlone E, Mandelli F, Cappare P, Pantaleo G, Traini T, Ferrini F. A 3 years retrospective study of survival for zirconia-based single crowns fabricated from intraoral digital impressions. J Dent. 2014 Sep;42(9):1151-5.

25. Fabbri G, Zarone F, Dellificorelli G, Cannistraro G, De LM, Mosca A, et al. Clinical evaluation of 860 anterior and posterior lithium disilicate restorations: retrospective study with a mean follow-up of 3 years and a maximum observational period of 6 years. Int J Periodontics Restorative Dent. 2014 Mar;34(2):165-77.

26. Dhima M, Paulusova V, Carr AB, Rieck KL, Lohse C, Salinas TJ. Practice-based clinical evaluation of ceramic single crowns after at least five years. J Prosthet Dent. 2014 Feb;111(2):124-30.

27. Vavrickova L, Dostalova T, Charvat J, Bartonova M. Evaluation of the three-year experience with all-ceramic crowns with polycrystalline ceramic cores. Prague Med Rep [Internet]. 2013 [cited 2015 Apr 23];114(1):22-34. Available from: http://pmr.cuni.cz/file/5648/PMR2013A0004.pdf

28. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. J Clin Epidemiol. 2009;62(10):e1-e34.

29. Behr M, Zeman F, Baitinger T, Galler J, Koller M, Handel G, et al. The clinical performance of porcelain-fused-to-metal precious alloy single crowns: chipping, recurrent caries, periodontitis, and loss of retention. Int J Prosthodont. 2014 Mar;27(2):153-60.

30. Hey J, Beuer F, Bensel T, Boeckler AF. Single crowns with CAD/CAM-fabricated copings from titanium: 6-year clinical results. J Prosthet Dent. 2014 Aug;112(2):150-4.

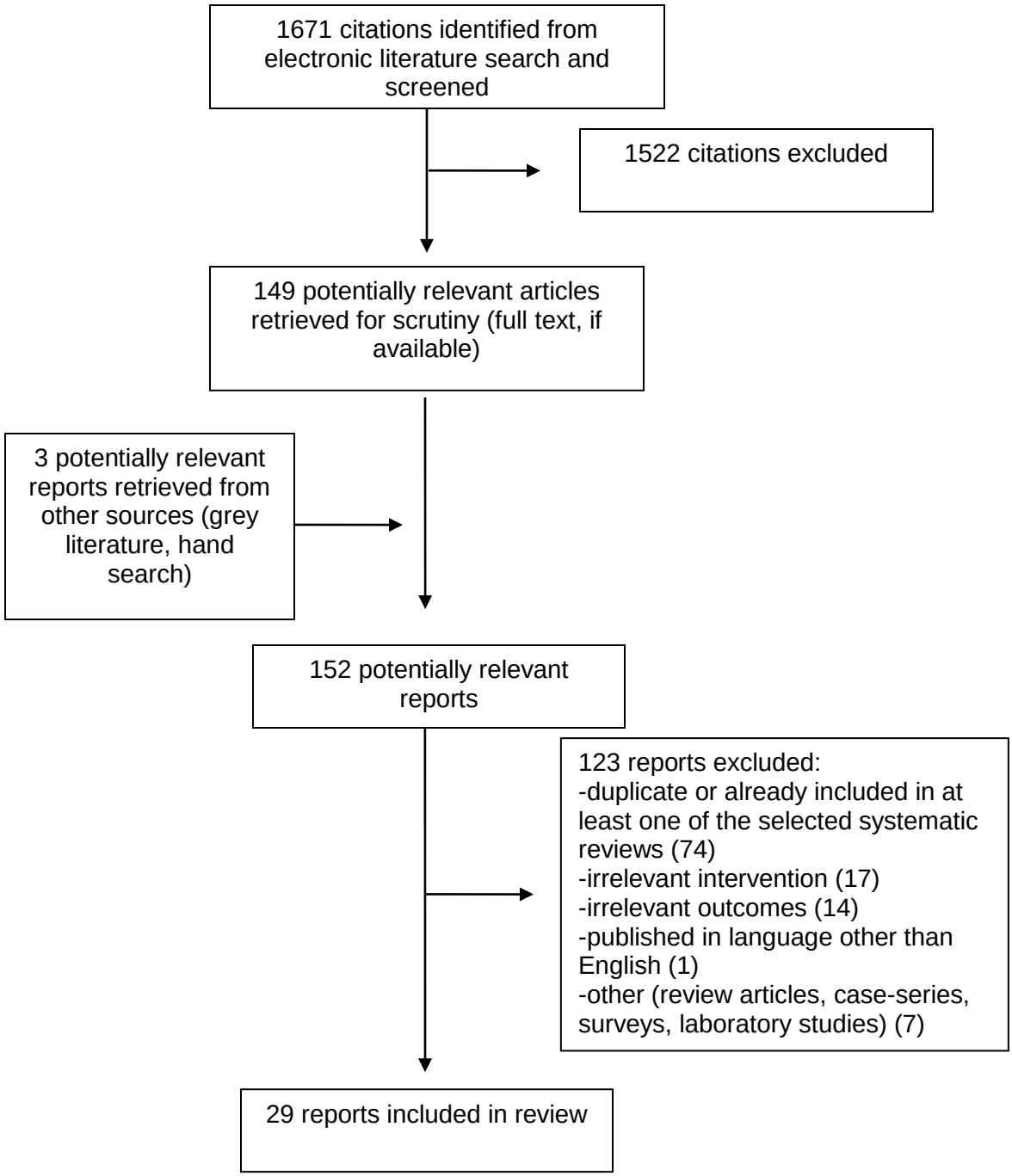
31. Takeichi T, Katsoulis J, Blatz MB. Clinical outcome of single porcelain-fused-to-zirconium dioxide crowns: a systematic review. J Prosthet Dent. 2013 Dec;110(6):455-61.

32. Ohlmann B, Bermejo JL, Rammelsberg P, Schmitter M, Zenthofer A, Stober T. Comparison of incidence of complications and aesthetic performance for posterior metal-free polymer crowns and metal-ceramic crowns: results from a randomized clinical trial. J Dent. 2014 Jun;42(6):671-6.

33. Burke FJ, Lucarotti PS. Ten-year outcome of crowns placed within the General Dental Services in England and Wales. J Dent. 2009 Jan;37(1):12-24.

34. Kelly PG, Smales RJ. Long-term cost-effectiveness of single indirect restorations in selected dental practices. Br Dent J. 2004 May 22;196(10):639-43.

APPENDIX 1: SELECTION OF INCLUDED STUDIES



APPENDIX 2: CHARACTERISTICS OF INCLUDED PUBLICATIONS

Table 2 : Characteristics of Included Systematic Reviews and Meta-Analyses - Longevity of All-ceramic/Porcelain Crowns

Primary studies included[a]	Population Characteristics	Intervention Comparator(s)	Clinical Outcomes, Length of Follow-Up
Pieger et al. 2014[6] – USA. Study objective was to analyze the short-term (1- to 5-year) and medium-term (5- to 10-year) survival rates of lithium disilicate single crowns and partial fixed dental prostheses.			
Search was conducted for the period between 1998 and 2013. 12 studies were included, but only 8 studies reported on single crowns: 1 RCT, 3 prospective, 1 retrospective, and 3 descriptive studies.	Two studies included patients from private clinics, while the five other studies included patients from University settings. The number of patients in each study ranged from 15 to 143 patients, and the number of restorations ranged from 40 to 263.	**Intervention:** Single crowns or partial fixed dentures fabricated with lithium disilicate. Only results for single crowns are reported in this review. **Comparator:** None	Interval survival rate and cumulative survival rate were the review outcomes. Failure was defined as the fracture of any part of a restoration that required the removal or remake of the restoration. Short-term survival was defined as the presence of the restoration in function 1 to 5 years after cementation, and medium-term survival was defined as the presence of the restoration in function 5 to 10 years after cementation. The length of follow-up ranged from six months to eleven years.
Larsson et al. 2014[7] – Sweden. Study objective was to evaluate the documented clinical success of zirconia-based crowns in clinical trials.			
Search was conducted for the period between 2000 and 2012. A total of 16 studies were included (7 studies reported in tooth-supported crowns, and 5 on both tooth-supported and implant-supported crowns): 1 RCT and 11 observational studies	The authors reported that the majority of studies were University-based. The number of patients was not reported, and the number of crowned teeth in each study ranged from 15 to 216 tooth.	**Intervention:** Single zirconia-based crowns supported by natural teeth or implants. Only results for natural teeth-supported crowns are reported in this review. **Comparator:** None	The primary outcomes were the cumulative survival and complication rates. Failure was defined as restorations having been removed. Complication was defined as one or more events affecting function and/ or esthetics. The length of follow-up ranged from one month to seven years
Wang et al. 2012[8] – China. Study objective was to evaluate the clinical fracture incidence of tooth-supported all-ceramic crowns according to restored tooth type			
Search was conducted for the period between 1995 and 2011. A total of 37 studies were included: 2 RCTs, 25	The authors did not report information about the source of data used in the included studies. The number of patients was not	**Intervention:** Single crowns supported by natural teeth. Crowns were fabricated using different	The primary outcome was the annual core and veneer fracture rates. Follow-up ranged from 36 to 97 months

Table 2 : Characteristics of Included Systematic Reviews and Meta-Analyses - Longevity of All-ceramic/Porcelain Crowns			
Primary studies included[a]	**Population Characteristics**	**Intervention Comparator(s)**	**Clinical Outcomes, Length of Follow-Up**
prospective, and 10 retrospective studies.	reported, and the number of crowned teeth in each study ranged from 17 to 1,039 tooth.	ceramic materials[a] **Comparator:** None	
[a] densely sintered alumina [Procera AllCeram] (8 studies); glass-infiltrated technique [In-Ceram Alumina or Spinell] (10 studies); feldspathic porcelain [Vita Mark II] (6 studies); glass-ceramic crowns [Dicor, Cerestore, and Hi-Ceram] (5 studies); lithium disilicate-reinforced glass-ceramic [IPS e.max Press, IPS Empress2] (4 studies); leucite-reinforced glass-ceramic [IPS Empress and Finesse] (6 studies); zirconia-based crowns [Lava Zirconia, and Procera Zirconia] (2 studies)			
Heintze et al. 2010[9] – Switzerland. Study objective was to evaluate the clinical fracture rate of crowns fabricated with the pressable, leucite-reinforced ceramic IPS Empress according to restored tooth type			
Search was conducted up to 2009. A total of 7 studies were included. The exact design of the included studies was not reported.	The authors did not report information about the source of data used in the included studies. The number of patients was not reported, and the number of crowned teeth in each study ranged from 37 to 802 tooth.	**Intervention:** Single crowns supported by natural teeth. Crowns were fabricated using leucite-reinforced glass-ceramic (IPS Empress) **Comparator:** None	The primary outcome variable was fracture of the crown. Failures not related to crown fractures but other reasons (fractured posts or recurrent caries) were not taken into consideration. Follow-up duration ranged from 2.9 to 7.5 years
Kassem et al. 2010[10] – Egypt. Study objective was to evaluate the clinical performance of porcelain molar crowns.			
Search was conducted for publications from 1997 to 2009. A total of 7 studies were included.	The authors did not report information about the source of data used in the included studies. The number of patients ranged from 26 to 136, and the number of crowned teeth in each study ranged from 19 to 208 tooth.	**Intervention:** Single all-ceramic crowns[a] **Comparator:** None	The primary outcome was the rate of failure. The authors did not provide specific definition to failure. Follow-up duration ranged from 5 to 10.5 years
[a] densely sintered alumina [Procera AllCeram] (5 studies); glass-infiltrated technique [In-Ceram Alumina or Spinell] (1 study); CEREC (1 study)			
Wittneben et al. 2009[11] – USA. Study objective was to evaluate the long-term clinical survival rates of single-tooth restorations manufactured with computer-aided design/computer assisted manufacturing (CAD/CAM) technology			
Search was conducted for publications from 1985 to 2000. A total of 16 studies were included in the review: two retrospective and fourteen prospective observational studies.	The authors did not report information about the source of data used in the included studies. The number of patients was not reported, and the number of crowned teeth in each study ranged from 8 to 1,010 tooth. The	**Intervention:** Inlay/only, core crown, crown, endo crown, reduced crown and veneers fabricated with a CAD/CAM system using different materials [a]. Only results for crowns were	The primary outcome was failure rate per 100 restoration years. The authors also reported the survival rate after five years. Failure was defined The follow-up duration ranged from 3 to 10 years; the mean duration was 8 years.

Table 2 : Characteristics of Included Systematic Reviews and Meta-Analyses - Longevity of All-ceramic/Porcelain Crowns			
Primary studies included[a]	**Population Characteristics**	**Intervention Comparator(s)**	**Clinical Outcomes, Length of Follow-Up**
	total number of restorations was 1,957.	reported in this report. **Comparator:** None	
[a] feldspathic ceramic; Galss-ceramic; oxide ceramic with aluminum oxide (In-Ceram Alumina); oxide ceramic with aluminum and magnumsium oxide (In-Ceram Spinell); resin based composite			
Wassermann et al. 2006[12] – Germany. Study objective was to evaluate the clinical performance of VITA In-Ceramic Alumina, Spinell, and Zirconia restorations.			
Search was conducted for publications from 1988 to 2006. A total of 21 studies were included in the review; only 10 studies reported results for single crowns.	The authors did not report information about the source of data used in the included studies. The number of patients was not reported, and the number of crowned teeth in each study ranged from 18 to 546 tooth.	**Intervention:** Crowns and fixed dental prostheses using In-Ceramic Alumina, Spinell, or zirconia restorations. Only results for crowns were reported in this report. **Comparator:** None	The primary outcome was survival rate and the cumulated survival rate. Failure was not explicitly defined in the review; however, the author reported the type and time of failure for each included study. The follow-up duration ranged from 2 to 3.5 years.
El-Mowafy et al. 2002[13] – Canada. Study objective was to evaluate the longevity and clinical performance of IPS-Empress restorations.			
Search was conducted for publications from 1988 to 2006. A total of 3 studies reported results for single crowns: one retrospective and one prospective and one case series studies.	The authors did not report information about the source of data used in the included studies. The number of patients ranged from 29 to 55, and the number of crowned teeth in each study ranged from 75 to 144 tooth.	**Intervention:** Crowns and onlyas fabricated with IPS-Empress crowns. Only results for crowns were used in this report. **Comparator:** None	The primary outcome was survival rate. The authors reported the cause of failures in the included studies. Follow-up ranged from 3 to 3.5 years.
Ho et al. 2012[14] – Canada. Study objective was to evaluate the clinical fracture resistance of CAD/CAM composite-based crowns compared to CAD/CAM all-ceramic crowns.			
The authors did not report date limits for their search. One study was included; the study was planned and initiated as randomized-controlled trial but was forced into observational study due the high failure rates in the intervention group.	The authors did not report information about the source of data used in the included studies. The number of patients was not reported, and the number of crowned teeth was 200.	**Intervention:** Crowns fabricated with CAD/CAM system using composite resin-based materials. **Comparator:** Crowns fabricated with CAD/CAM system using all ceramic materials.	The primary outcome was survival rate. The authors reported that success criteria in the included study were no anatomical changes, veneer chipping, seriously compromised esthetics, loosening, fracture or loss of integrity at margins. Follow-up duration was 3 years.

Table 2 : Characteristics of Included Systematic Reviews and Meta-Analyses - Longevity of All-ceramic/Porcelain Crowns			
Primary studies included[a]	**Population Characteristics**	**Intervention Comparator(s)**	**Clinical Outcomes, Length of Follow-Up**
Alwash et al. 2010[15] **– Canada.** Study objective was to assess the clinical efficacy of single zirconium-based crowns on posterior teeth			
The literature search included publications from 1995 to 2010. Three studies were included: two randomized-controlled trials and one retrospective study.	The authors did not report information about the source of data used in the included studies. The number of patients was 20, 224, and 161 in the three studies. The number of placed crowns: **Study I**: 15 Cecon zirconia, and 15 In-Ceram zirconia **Study II**: 123 CAD/CAM and 101 gold crowns **Study II**I: 216 CAD/CAM crowns	**Intervention:** Zirconium oxide crowns fabricated on posterior teeth. **Comparator:** Porcelain-fused to metal crowns fabricated on posterior teeth.	The primary outcome was survival rate. Failure definitions in the three studies included fractures of core, veneering or abutments in two studies. One study focused on marginal integrity only. Follow-up duration was 2 years in two studies and 3 years in the third one.

Table 3: Characteristics of Included Randomized and Non-Randomized Clinical Studies - Longevity of All-ceramic/Porcelain Crowns

Study and Patient Characteristics	Intervention(s) Comparator(s)	Clinical Outcomes
Rammelsberg et al. 2005,[16] Randomized controlled trial – Germany. The objective of this study was to evaluate the influence of location and preparation design on the survival and complication rate of metal-free polymer crowns		
A total of 71 patients and 117 crowns were included in the trial. The authors did not report on the setting of this trial (hospital/ university or private practice). Treatments were provided by six dentists. The authors reported that the main inclusion criterion was the necessity to cap a tooth (because of the carious destruction of a tooth) but they did not report if they included endodontically treated teeth with or without post	**Intervention**: teeth were prepared using chamfer finishing line and occlusal reduction of at least 1 mm **Comparator**: teeth were prepared using shoulder finishing line and occlusal reduction of at least 1 mm Both groups received single crowns made with metal free Artglass (Heraeus Kulzer, Wehrheim, Germany).	Survival rate was the primary outcome. Failure was defined as fracture (total or partial) or decementation. Follow-up duration was three years.
Toman et al.[17] Prospective uncontrolled study – Turkey. Study objective was to evaluate the clinical performance of lithium disilicate crowns		
A total of 35 patients and 125 crowns were placed between 2001 and 2007. Patients were treated at a university-base setting. It was reported that endodontically treated teeth were included in the study.	**Intervention**: single lithium disilicate (IPS Empress 2) crowns **Comparator:** none	Survival rate was the primary outcome. Failure was defined as fracture or partial debonding that exposed the tooth structure, impaired esthetic quality or function, replacement of the crown due to extraction, or fracture of the abutment tooth. The follow-up ranged from 12 to 156 months.
Tartaglia et al.[18] 2014 Prospective uncontrolled study – Italy. Study objective was to the clinical performance of zirconia-based prosthesis		
A total of 88 patients and 150 single crowns were included in the study. Patients were treated in a general dental private practice. The author included prosthesis supported by implants and natural teeth, but the majority (202/228) of single crowns were made on natural teeth. The authors did not report if they considered endodontically treated teeth in this study.	**Intervention**: zirconia-based single and multiple units crowns. Only results for single crowns are reported in this review **Comparator:** none	Survival rate was the primary outcome. Failure was defined as need for replacement or removal of the prosthesis, fracture and loss of retention, extraction of the abutment tooth or loss of osteointegration of the implant, and secondary caries or persistent pain. The follow-up period was seven years.

Table 3: Characteristics of Included Randomized and Non-Randomized Clinical Studies - Longevity of All-ceramic/Porcelain Crowns

Study and Patient Characteristics	Intervention(s) Comparator(s)	Clinical Outcomes
Galindo et al.[19] 2011 Prospective uncontrolled study – Switzerland. Study objective was to estimate long-term survival of alumina crowns in anterior and posterior areas over an observation period of up to 10 years.		
A total of 50 patients and 155 single crowns were included in the study. Of these patients, ten subjects had relocated, 6 refused to participate, and 4 had died; only 112 crowns were included in the analysis. Patients were treated from 1997 and 2005 by University students.	**Intervention**: crowns were fabricated with densely sintered aluminum oxide (Procera All-Ceram system) as the core material. Crown design and manufacturing were computer-assisted (CAD/CAM) **Comparator:** none	Survival rate was the primary outcome. The authors gave two definitions for failure; treatment failure and technical failure. Treatment failure was defined as crown or tooth loss and separated into technical or biological failures. Technical failures included core or veneering fracture of the crown, and biological failures included caries, periodontal or endodontic disease, and tooth fracture. Patients were followed up to 10 years, and mean follow-up time was 7.8 years.
Reich et al.[20] 2010 Prospective uncontrolled study - Germany. Study objective was to evaluate the clinical performance of chairside-generated crowns.		
A total of 34 patients and 41 single crowns were included in the study. Of these, 32 patients and 39 crowns were available for the two-year follow-up. Patients were treated by four dentists in a University-based setting and a private dental practice setting.	**Intervention**: crowns were fabricated chairside using Cerec 3D system and lithium disilicate ceramic material. Optical impressions were used, and crowns were fabricated using computer assisted design and manufacturing. **Comparator:** none	Survival rate was the primary outcome. Failure was defined as lost crown or a crown with poor rating due to recurrent caries. Follow-up was two years.
Mansour et a.[21] 2008 Prospective uncontrolled study – Jordan. Study objective was to evaluate the clinical performance of IPS-Empress 2 all-ceramic crowns.		
64 patients and 82 crowns were included in the study. Patients were treated in private dental practices. The authors did not report if endodontically treated teeth were eligible for inclusion.	**Intervention**: crowns were fabricated with leucite glass-ceramic (IPS-Empress 2 system) . **Comparator:** none	Survival rate was reported in this study, but the authors did not provide an explicate definition for failure. Follow-up duration ranged from 15 to 57 months.

Table 3: Characteristics of Included Randomized and Non-Randomized Clinical Studies - Longevity of All-ceramic/Porcelain Crowns

Study and Patient Characteristics	Intervention(s) Comparator(s)	Clinical Outcomes
Valenti 2015,[22] Retrospective uncontrolled study – Italy. Study objective was the clinical performance of lithium disilicate crowns with a feather-edge finish line over a 9-year period		
A total of 59 patients and 110 crowns were included in the trial. Patients were recruited from one private practice. The authors did not report inclusion criteria, and was not clear if the author included endodontically treated teeth with or without core and post.	**Intervention**: teeth were prepared using feather-edge finish line and restored with CAD/CAM made-lithium disilicte crowns **Comparator:** none	Survival was the primary outcome, and it was defined as the period of time starting at baseline and ending when the clinician estimated that an irreparable failure of the crown had occurred. Follow-up period was up to 9 years.
Guncu et al.[23] Retrospective uncontrolled study – Turkey. Study objective was to evaluate the 5-year clinical performance of zirconia-based crowns		
A total of 148 patients and 618 single crowns were included in the study. Patients were treated university and private practices during the period 2007 and 2008. A total of 191 teeth were treated endodontically.	**Intervention**: single and multiple unit zirconia-base crowns build on natural teeth. Only results of single crown are reported in this review **Comparator:** none	Survival rate was the primary outcome. The authors considered failure as fractured core or veneering porcelain that require remake. Follow-up period was up to 5 years.
Gherlone et al.[24] 2014 Retrospective uncontrolled study – Italy. The study objective was to evaluate the clinical performance of glass-ceramic/zirconia crowns fabricated using intraoral digital impressions		
A total of 70 consecutive patients and 86 single glass-ceramic/zirconia crowns were included in the study. Patients were treated by one dentist in single general dental private practice. All included teeth were supported by natural teeth. The authors did not report if they considered endodontically treated teeth in this study.	**Intervention**: Abutment teeth were prepared by with knife-edge finish line. Impressions were made with optical Scanning. Single crowns were made from milled zirconia cores and glass-ceramic veneering **Comparator:** none	Success rate was the primary rate. Failure was defined lost or chipped crowns. The follow-up period was three years.
Fabbro et al.[25] 2014 Retrospective uncontrolled study – Italy. The study objective was to evaluate the clinical performance of lithium disilicate restorations		
The study included 312 patients and 480 crowns. Patients were treated in the period from 2006 and 2010 in a university-based setting. The authors included restorations supported by natural teeth and implants; however, the majority of crowns (52/480) were	**Intervention**: restorations fabricated using pressed lithium disilicate using both monolithic and layered techniques. Only results for tooth-supported single crowns are reported in this review. **Comparator:** none	Cumulative survival and cumulative success rates were the primary outcomes. However, the authors did not provide the difference between the two outcomes. Failure was defined as any mechanical

Table 3: Characteristics of Included Randomized and Non-Randomized Clinical Studies - Longevity of All-ceramic/Porcelain Crowns		
Study and Patient Characteristics	**Intervention(s) Comparator(s)**	**Clinical Outcomes**
supported by natural teeth. It was reported that endodontically treated teeth were included in the study.		complication. The follow-up period ranged from 12 to 72 months.
Dhima et al.[26] 2014 Retrospective uncontrolled study – USA. Study objective was to evaluate the clinical performance of ceramic single crowns		
A total of 59 patients and 226 single crowns were included in the study. Authors invited all eligible patients for a follow-up visit. Patients were treated in Mayo Clinic Department of Dental Specialities who satisfy the inclusion criteria. The author included prosthesis supported by implants and natural teeth.	**Intervention**: crowns fabricated with ceramic systems included bilayer (alumina core, zirconia core) and monolayer (pressed lithium disilicate, zirconia). **Comparator:** none	Survival rate was the primary outcome. Failure was defined as crowns that needed to be replaced. Patients were follow-up up to 6 years, the mean follow-up duration was 3.3 years.
Vavrickova et al.[27] 2013 Retrospective uncontrolled study – Czech Republic. Study objective was to evaluate the clinical outcomes of all-ceramic crowns three years after placement		
A total of 33 patients and 121 crowns were included in the study. Patients were treated in two private dental practices. 102/121 crowns were supported by vital natural teeth, and 19/121 were supported by endodontically treated teeth.	**Intervention**: crowns fabricated with all-ceramic systems; the core material was alumina core [n = 19] and zirconia core [n = 102], and the veneering material was zirconium oxide (Lava Ceram). **Comparator:** none	Success rate was the primary outcome. Failure was defined as aesthetics or function of the crown was damaged such that it had to be removed and replaced. Follow-up period was up to three years

Table 4: Characteristics of Included Non-Randomized Clinical Studies - Longevity of Porcelain-fused-to-Metal Crowns		
Study and Patient Characteristics	**Intervention(s) Comparator(s)**	**Clinical Outcomes**
Hey et al. 2014,[30] Prospective uncontrolled study - Germany. The study objective was to evaluate Computer-aided design/computer-aided manufacturing (CAD/CAM) titanium ceramic single crowns after 6 years in function		
A total of 21 patients and 41 crowns were included in the study. The study was based on data from a University prosthodontic department. The authors did not report when these crowns were inserted.	**Intervention:** single porcelain-fused to metal crowns made with titanium coping using computer-aided design/computer-aided manufacturing (CAD/CAM) technology.	The primary outcome was survival rate. Failure was defined as fracture. Follow-up was six years.
Behr et al. 2014,[29] Retrospective uncontrolled study - Germany. The study objective was to evaluate the frequency and time to chipping and facing failures, recurrent caries, periodontitis and loss of retention of porcelain fused to metal crowns		
The study was based on data from a University prosthodontic department. It included 997 single crowns inserted between 1984 and 2009.	**Intervention:** single porcelain-fused to metal crowns made with precious metal only.	The primary outcome was survival rate. Failure was defined as a crown/tooth that lost its function and a new crown had to be made. The follow-up duration was up to 14 years (median 4.3 years)

Table 5 : Characteristics of Included Systematic Reviews and Meta-Analyses - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns			
Primary studies included[a]	**Population Characteristics**	**Intervention Comparator(s)**	**Clinical Outcomes, Length of Follow-Up**
Sailer et al. 2015[2] Systematic review – Switzerland. Study objective was to evaluate the 5-year survival of metal-ceramic and all-ceramic tooth-supported single crowns (SCs)			
Literature search included publications from 1991 to 2013. A total of 67 studies were included in the review: 51 studies evaluate all-ceramic crowns and 17 studies evaluated porcelain-fused to metal crowns. Of these, four studies were RCTs, and the remaining 63 studies were observational (retrospective or prospective). Only one RCT compared all-ceramic and metal-ceramic crowns.	Twenty studies were based on private practice data, and the remaining studies were University-based. The number of patients ranged from 10 to 456. The total number of placed crowns was 14,156 with a mean follow-up of 5.8 years	**Intervention:** All-ceramic crowns fabricated on single teeth (51 studies[a]) **Comparator:** Porcelain-fused to metal crowns fabricated on single teeth (17 studies).	The primary outcome was 5-year cumulative survival. The authors did not provide an explicit definition for failure. Secondary outcomes included technical and biological complications. Technical complications included framework fracture, ceramic fracture, ceramic chipping, marginal discoloration, loss of retention and poor esthetics. The mean follow-up was 5.8 years
[a] Densely sintered zirconia (9 studies); Densely sintered alumina (8 studies); Glass-infiltrated alumina (15 studies); Leucit/Lithium disilicate reinforced glass ceramics (12 studies); Feldspathic/silica-based ceramic (10 studies)			
Takeichi et al. 2013[31] Systematic review – USA. Study objective was to evaluate the clinical survival rates of Zirconia all-ceramic single crowns on anterior and posterior teeth and to compare them with metal ceramic crowns			
The authors search studies published between 1993 and 2011. A total of 19 studies were included: four studies evaluated all-ceramic crowns, and 15 studies evaluated metal-ceramic crowns. The design of each included study was not reported.	The authors did not report information about the source of data used in the included studies. The number of patients was not reported. A total of 3621 crowns were analyzed.	**Intervention:** All-ceramic (porcelain fused to zirconia) crowns fabricated on single natural teeth (4 studies, 300 single crowns) **Comparator:** Porcelain-fused to metal crowns fabricated on single natural teeth (19 studies, 3321 single crowns).	The primary outcome was annual failure rate. Failure was considered if a biologic or technical complication occurred that required the replacement or repair of the crown or the extraction of the tooth. Technical complications included fracture of the framework, fracture of the veneering porcelain, marginal discoloration, excessive occlusal wear, and loss of retention Follow-up ranged from 24 to 39 months

Table 6: Characteristics of Included Randomized and Non-Randomized Clinical Studies - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns		
Study and Patient Characteristics	**Intervention(s) Comparator(s)**	**Clinical Outcomes**
Ohlmann et al. 2014,[32] Randomized controlled trial – Germany. The objective of the study was to evaluate and compare the clinical performance of posterior, metal-free polymer and metal–ceramic crowns.		
A total of 66 patients and 120 single crowns were included in the trial. Patients were recruited from a University-based setting. The main inclusion criterion was the need for full-coverage restoration, including root-canal-treated teeth.	All crowns were placed on posterior teeth. **Intervention 1**: crowns were made from polymer composite resin and had a glass–fibre framework (40 teeth) **Intervention 2**: crowns were made from polymer composite resin without glass–fibre framework (40 teeth) **Comparator**: metal-ceramic crowns were used (40 teeth)	Primary endpoints were incidence of complications, plaque status, and aesthetic performance. Follow-up duration was up to 6 years
Burke et al. 2009,[33] Retrospective non-randomized controlled study – UK. The study objective was evaluate the factors associated with the need for re-intervention on a crown, and the times to re-intervention		
The study was based on a data set of randomly selected patients who received one or more indirect restorations in the period from 1990 and 2002. A total of 88,000 patient's records and 47,474 crown restoration occasions were included over a period of 11 years.	The study included four types of crowns: 1. Metal crown (7,817) 2. Porcelain jacket (1,434) 3. Bonded metal-porcelain crowns (38,166) 4. Synthetic resin full crown (57)	The primary outcome was he time to re-intervention of teeth.

Table 7: Characteristics of Included Cost Studies			
Study Objectives & Design	**Data collection/ Assumptions**	**Interventions**	**Outcomes**
Kelly et al, 2004[34] – Australia			
Determine the relative cost-effectiveness of alternative methods for restoring large tooth substance loss in adults.	• The study included was based on retrospective survival data of molar restorations placed in three private clinics with the participation f none dentists • All restorations were placebo before 1985 and followed-up for at least 10 years • Data were collected patients records • Survival analysis excluded (censored) crowns removed due to endodontic treatment or periodontal diseases • Restoration costs were discounted to the mean costs in South Australian metropolitan in 1992.	Posterior dental restorations: • Full gold crowns • Ceramo-metal crowns • Cast onlay • Porcelain jacket crowns • Class I amalgam • Class II amalgam • Class IV resin composite	Cost-effectiveness of the dental restorative treatment defined as the difference in the discounted costs incurred between treatment A and treatment B divided by the difference in their effectiveness (restoration survival). Lower values meant higher benefits derived. Effectiveness was based on restoration survival; however, survival rate was not defined in the report.

APPENDIX 3: CRITICAL APPRAISAL OF INCLUDED PUBLICATIONS

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns

Strengths	Limitations
Pieger et al. 2014[6] Systematic Review – USA. Study objective was to analyze the short-term (1- to 5-year) and medium-term (5- to 10-year) survival rates of lithium disilicate single crowns and partial fixed dental prostheses.	
• Multiple investigators screened two major databases (PubMed and Cochrane library), and a supplemental search was done based on the references of the included studies • Inclusion and exclusion criteria were clearly described • The authors used actuarial method for life table analysis to calculate the interval survival rate and the cumulative survival rate. This method is acceptable and appropriate for survival analyses.	• The authors did not report whether the evaluated prostheses were supported by natural teeth or implants. Therefore, the generalizability of findings is uncertain. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases. • Most of the included studies 5/7 (71.4%) did not report the range of follow-up, and it is not clear who the authors managed to calculate the survival rates without this information.
Larsson et al. 2014[7] Systematic Review – Sweden. Study objective was to evaluate the documented clinical success of zirconia-based crowns in clinical trials.	
• Multiple investigators screened three databases (PubMed, Cochrane library, and Science Direct), and a supplemental search was done based on the references of the included studies and hand search of major dental journals • The authors reported the search terms for each database, and they clearly reported the inclusion criteria. • The authors used life table analyses to calculate the cumulative survival and complication rates. This method is acceptable and appropriate for survival analyses.	• The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
Wang et al. 2012[8] Systematic Review – China. Study objective was to evaluate the clinical fracture incidence of tooth-supported all-ceramic crowns according to restored tooth type	
• Multiple investigators screened four databases (PubMed, Embase, Cochrane library, and the Chinese Biomedical Literautre Database), and a supplemental search was done based on the references of	• The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns	
Strengths	**Limitations**
the included studies and hand search of major dental journals. • The inclusion and exclusion criteria were clearly reported. • The authors used acceptable statistical analyses. They used Poisson distribution to build a regression model; the model accounted for the number of crowns at follow-up, mean follow-up time, and the tooth type.	except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
Heintze et al. 2010[9] Systematic Review – Switzerland. Study objective was to evaluate the clinical fracture rate of crowns fabricated with the pressable, leucite-reinforced ceramic IPS Empress according to restored tooth type	
• The inclusion and exclusion criteria were clearly reported.	• Only one database was searched, and authors did not complement this search with any grey literature search. • The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases. • The authors used Poisson distribution to build a regression model that tested the effect of tooth type. However, the authors did not account for the follow-up time in each study. Instead they considered that risk of fracture is constant.
Kassem et al. 2010[10] Systematic Review – Egypt. Study objective was to evaluate the clinical performance of porcelain molar crowns.	
• Literature search was conducted by two reviewers	• Only one database was searched, and authors did not complement this search with any grey literature search. • The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns	
Strengths	**Limitations**
	cases. • The authors did not account for the follow-up time in each study.
Wittneben et al. 2009[11] Systematic Review – USA. Study objective was to evaluate the long-term clinical survival rates of single-tooth restorations manufactured with computer-aided design/computer assisted manufacturing (CAD/CAM) technology	
• Multiple reviewers screened two databases (PubMed and Embase), • The inclusion and exclusion criteria were clearly reported. • The statistical analyses accounted for time restorations in each study were exposed to the risk of failure. However, the authors assumed that this risk is constant which might not be very accurate.	• The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
Wassermann et al. 2006[12] Systematic Review – Germany. Study objective was to evaluate the clinical performance of VITA In-Ceramic Alumina, Spinell, and Zirconia restorations.	
• The authors performed the literature search of one database (PubMed), and they complemented their search with a manual screening of several dental journals. • The authors provided an evaluation of evidence based on the type of study design. All included studies were based on evidence obtained from at least one other type of well-designed quasi-experimental study. • The authors estimated the cumulative survival rate which account for the time restorations were exposed to risk of failure.	• The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
El-Mowafy et al. 2002[13] Systematic Review – Canada. Study objective was to evaluate the longevity and clinical performance of IPS-Empress restorations.	
•	• Only one database was searched, and authors did not complement this search with any grey literature search. • The authors did not report the source of data used in the included studies. • The authors did not evaluate the quality of and the risk of bias in the included studies • From the reported information, all studies except one were uncontrolled small observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns	
Strengths	**Limitations**
	• The authors did not account for the follow-up duration for the calculation of survival rate
Ho et al. 2012[14] Systematic Review – Canada. Study objective was to evaluate the clinical fracture resistance of CAD/CAM composite-based crowns compared to CAD/CAM all-ceramic crowns.	
• Multiple reviewers screened three databases (PubMed, SCOPUS and Google scholar) • The inclusion and exclusion criteria were clearly reported. • The authors evaluated the quality of the included study	• The authors did not report the source of data used in the included studies. • The authors did not account for the follow-up duration for the calculation of survival rate
Alwash et al. 2010[15] Systematic Review – Canada. Study objective was to assess the clinical efficacy of single zirconium-based crowns on posterior teeth	
• Multiple reviewers screened three databases (PubMed, Ovid Medline, SCOPUS and Cochrane databse) • The inclusion and exclusion criteria were clearly reported. • The authors evaluated the quality of the included study	• The authors reported that the selection criteria included porcelain fused to metal crowns as control group; however, they included three studies with different control groups (one study had Cercon zirconia, one study had gold crowns, and the third study was uncontrolled). • The authors did not account for the follow-up duration for the calculation of survival rate
Rammelsberg et al. 2005,[16] Randomized controlled trial – Germany. The objective of this study was to evaluate the influence of location and preparation design on the survival and complication rate of metal-free polymer crowns	
• The authors managed to follow-up all included patients. • The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The authors did not report the randomization method or the randomization concealment procedure. • The authors did not report the setting from which patients were recruited. • The authors included 71 patients, but they did not report any information to show that the trial size was based on power calculation. • Blinding was not feasible due to the nature of interventions; however, this wasn't likely to introduce a bias to the primary outcome assessment because it was an objective clinical outcome (fracture). • The authors did not reported detailed results for each of the intervention groups. Instead, they reported the overall number of failure and survival rate.
Toman et al.[17] Prospective uncontrolled study – Turkey. Study objective was to evaluate the clinical performance of lithium disilicate crowns	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The author did not indicate how patients were chosen for inclusion in the study. It was not clear that the author included all patients

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns	
Strengths	**Limitations**
• The authors reported the percentage of endodontically treated teeth, and they reported their survival rate.	treated with these crowns, or if the included patients were selected from a bigger pool of patients
Tartaglia et al.[18] Prospective uncontrolled study – Italy. Study objective was to the clinical performance of zirconia-based prosthesis	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The authors indicated that 50 patients (72 single crowns on natural teeth) were lost to follow-up at year seven. But they did not give information on the status of their prostheses before they stopped the follow-up visits. • The authors did not use data imputation methods that account for the missing data. • Patients were recruited from one private dental practice, and it is not clear if the results obtained from this study would be generalizable to other settings. • The authors reported overall estimates for failures/ survival, and they did not report the results by type of crown support or the number of units (single versus multiple units).
Galindo et al.[19] 2011 Prospective uncontrolled study – Switzerland. Study objective was to estimate long-term survival of alumina crowns in anterior and posterior areas over an observation period of up to 10 years	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure. However, the authors did not apply censoring methods to account for the missing data	• The authors did not report any inclusion criteria, and it was not clear how the included patients were selected. • The authors did not report success rate by the tooth vitality status which might affect crown success rate.
Reich et al.[20] 2010 Prospective uncontrolled study - Germany. Study objective was to evaluate the clinical performance of chairside-generated crowns.	
• The authors used appropriate survival analyses method, but they failed account for missing data by applying censoring methods.	• The authors did not report any inclusion criteria, and it was not clear how the included patients were selected.
Mansour et a.[21] 2008 Prospective uncontrolled study – Jordan. Study objective was to evaluate the clinical performance of IPS-Empress 2 all-ceramic crowns.	
• The authors used appropriate survival analyses method.	• The authors did not report any inclusion criteria, and it was not clear how the included patients were selected.
Valenti 2015,[22] Retrospective uncontrolled study – Italy. Study objective was to evaluate the clinical performance of lithium disilicate crowns with a feather-edge finish line over a 9-year period	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The author did not indicate how patients were chosen for inclusion in the study. It was not clear that the author included all patients treated with these crowns, or if the included patients were selected from a bigger pool of patients

Table 8: Strengths and Limitations - Longevity of All-ceramic/Porcelain Crowns	
Strengths	**Limitations**
Guncu et al.[23] Retrospective uncontrolled study – Turkey. Study objective was to evaluate the 5-year clinical performance of zirconia-based crowns	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	
Gherlone et al.[24] 2014 Retrospective uncontrolled study. The study objective was to evaluate the clinical performance of glass-ceramic/zirconia crowns fabricated using intraoral digital impressions	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• Patients were recruited from one private dental practice, and it is not clear if the results obtained from this study would generalizable to other settings.
Fabbro et al.[25] 2014 Retrospective uncontrolled study – Italy. The study objective was to evaluate the clinical performance of lithium disilicate restorations	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• Patients were recruited from one private dental practice, and it is not clear if the results obtained from this study would generalizable to other settings.
Dhima et al. 2014 Retrospective uncontrolled study – USA. Study objective was to evaluate the clinical performance of ceramic single crowns	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The authors did not report if all patients they contacted accepted to attend the follow-up visit. They reported the number of patients who accepted to participate in the study, but there were no information to indicate the rate of response. • The authors did not report the number of crowns supported by implants and how the type of support might affect crowns survival.
Vavrickova et al.[27] 2013 Retrospective uncontrolled study – Czech Republic. Study objective was to evaluate the clinical outcomes of all-ceramic crowns three years after placement	
• The authors used appropriate analyses plan to evaluate the effect of location and preparation design on crown failure	• The authors did not report any inclusion criteria, and it was not clear how the included patients were selected. • The authors did not report success rate by the tooth vitality status which might affect crown success rate.

Table 9: Strengths and Limitations - Longevity of Porcelain-fused-to-Metal Crowns	
Strengths	**Limitations**
Hey et al. 2014,[30] Prospective uncontrolled study. The study objective was to evaluate Computer-aided design/computer-aided manufacturing (CAD/CAM) titanium ceramic single crowns after 6 years in function	
• The authors accounted for the time each crown was exposed to failure. And they used acceptable statistical analysis to describe survival rates.	• The inclusion criteria were not reported. • Four crowns were lost to follow-up after the fourth year. The author excluded them for analysis without applying any imputation method.
Behr et al. 2014,[29] Retrospective uncontrolled study. The study objective was evaluate the frequency and time to chipping and facing failures, recurrent caries, periodontitis and loss of retention of porcelain fused to metal crowns	
• The inclusion criteria were clearly reported • The authors accounted for the time each crown was exposed to failure. And they used acceptable statistical analysis to describe survival rates.	• The authors included data on crowns installed from the year 1984 up to 2009; materials used in the earlier period of the study might not be representative to materials used these days.

Table 10: Strengths and Limitations of Studies - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns	
Strengths	**Limitations**
Sailer et al. 2015[2] – Switzerland. Study objective was to evaluate the 5-year survival of metal-ceramic and all-ceramic tooth-supported single crowns (SCs)	
• Two investigators searched four databases (PubMed, Embase, Cochrane, Central Register of Controlled Trials), and they complemented their search with manual screening of references of the included full texts. • The inclusion and exclusion criteria were clearly reported. • The authors reported the rate attrition (failure of follow-up) in the included studies. • The statistical analyses accounted for time restorations in each study were exposed to the risk of failure. However, the authors assumed that this risk is constant which might not be very accurate. • The authors conducted indirect comparison between the different interventions; however, they did not provide any consistency analysis for results obtained from the indirect comparison to those obtained from direct comparison.	• The authors did not evaluate the quality of and the risk of bias in the included studies • Most of the included studies were observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
Takeichi et al. 2013[31] – USA. Study objective was to evaluate the clinical survival rates of Zirconia all-ceramic single crowns on anterior and posterior teeth and to compare them with metal ceramic crowns	
• The inclusion and exclusion criteria were clearly reported. • The authors reported the rate attrition (failure of follow-up) in the included studies. • The statistical analyses accounted for time restorations in each study were exposed to the risk of failure. However, the authors assumed that this risk is constant which might not be very accurate.	• One investigator searched one database (PubMed) and complemented the screening with hand search of references of the included full texts. • The authors estimated the failure rate for each type of crown a part, but they did not conduct a formal comparison between the two interventions • The authors did not evaluate the quality of and the risk of bias in the included studies • Most of the included studies were observational studies. The authors did not provide information to evaluate the potential of selective reporting of the more successful cases.
Ohlmann et al. 2014,[32] Randomized controlled trial – Germany. The objective of the study was to evaluate and compare the clinical performance of posterior, metal-free polymer and metal–ceramic crowns.	
• The authors used appropriate analyses plan to evaluate the effect of location and	• The authors did not report the randomization method or the

Table 10: Strengths and Limitations of Studies - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns	
Strengths	**Limitations**
preparation design on crown failure • Sample size was based on statistical power calculation.	randomization concealment procedure. • Blinding was not feasible due to the nature of interventions; this could introduce a bias to the primary outcome assessment because it included subjective evaluation of esthetics. • The authors excluded 9/120 teeth from analysis because patients did not keep regular appointments. They did not attempt to use any adjustment method to account for the missing data. • The analysis used one of the tested interventions (polymer composite resin with glass–fibre framework) as a reference; an appropriate analysis would consider metal-ceramic as the reference. The impact of this analysis was the absence of testing the relative efficacy of metal-ceramic versus polymer composite resin without glass–fibre framework
Burke et al. 2009,[33] Controlled observational study – UK. The study objective was evaluate the factors associated with the need for re-intervention on a crown, and the times to re-intervention	
• The authors constructed the databased using random selection method by the birth of date. • The original database represented the National Health Service- General Dental Services in England and Wales. • The authors used appropriate statistical methods to evaluate the effect of crown type on its survival.	• The database included crowns made up to 2002. Therefore, newer ceramic materials might not be available or familiar during the evaluation period used by this study.

Table 11: Strengths and Limitations of Economic Studies	
Strengths	**Limitations**
Kelly et al, 2004[34] – Australia	
• The cost-effectiveness analyses were based on real data obtained from three different dental practices. • Prices were adjusted (discounted) from the time of teeth restoration to the time when the study was conducted	• The selection of restoration was not randomized, and the survival of crowns might be affected by the cause behind selecting the type of restoration. • The study was based on restorations placed before 1985, dental materials used in crown fabrication have been changed considerably since then. This may affect the generalizability of the study results.

APPENDIX 4: MAIN STUDY FINDINGS AND AUTHOR'S CONCLUSIONS

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

<table>
<tr><th colspan="6">Main Study Findings</th><th>Author's Conclusions</th></tr>
<tr><td colspan="7">Pieger et al. 2014[6] Systematic review – USA. Study objective was to analyze the short-term (1- to 5-year) and medium-term (5- to 10-year) survival rates of lithium disilicate single crowns and partial fixed dental prostheses.</td></tr>
<tr><td>Time interval</td><td colspan="2">Number of studies ; failures/ restorations</td><td>Number of restorations at risk</td><td>Interval survival rate (%)</td><td>Cumulative survival rate (%)</td><td rowspan="12">The short-term evidence (1 to 5 years) indicates an excellent survival rate for lithium disilicate crowns. The evidence for medium-term survival is limited to one observational study.</td></tr>
<tr><td>0-1</td><td colspan="2">8; 0/696</td><td>696</td><td>100</td><td>100</td></tr>
<tr><td>1-2</td><td colspan="2">7; 0/505</td><td>409.5</td><td>100</td><td>100</td></tr>
<tr><td>2-3</td><td colspan="2">5; 2/386</td><td>326.5</td><td>99.38</td><td>99.38</td></tr>
<tr><td>3-4</td><td colspan="2">4; 2/341</td><td>318.5</td><td>99.37</td><td>98.76</td></tr>
<tr><td>4-5</td><td colspan="2">1; 2/261</td><td>221</td><td>99.09</td><td>97.86</td></tr>
<tr><td>5-6</td><td colspan="2">1; 2/260</td><td>259.5</td><td>99.22</td><td>97.11</td></tr>
<tr><td>6-7</td><td colspan="2">1; 1/260</td><td>260</td><td>99.61</td><td>96.74</td></tr>
<tr><td>7-8</td><td colspan="2">1; 0/259</td><td>258.5</td><td>100</td><td>96.74</td></tr>
<tr><td>8-9</td><td colspan="2">1; 0/259</td><td>259</td><td>100</td><td>96.74</td></tr>
<tr><td>9-10</td><td colspan="2">1; 0/259</td><td>259</td><td>100</td><td>96.74</td></tr>
<tr><td>10-11</td><td colspan="2">1; 0/259</td><td>259</td><td>100</td><td>96.74</td></tr>
<tr><td colspan="7">Larsson et al. 2014[7] Systematic review – Sweden. Study objective was to evaluate the documented clinical success of zirconia-based crowns in clinical trials.</td></tr>
<tr><td>Time interval</td><td colspan="2">Number of studies ; failures/ restorations</td><td>Number of restorations at risk</td><td>Cumulative complication rate (%)</td><td>Cumulative survival rate (%)</td><td rowspan="4">Survival rates of tooth-supported and zirconia-based crowns were comparable with the survival rate of porcelain-fused to-metal crowns. The authors emphasized that these results were based on small number of uncontrolled studies.

Reviewer's comment: The authors did not provide comparative analysis between zirconia and porcelain-fused-to-metal crowns. Therefore, such comparison should not be made based on this review.</td></tr>
<tr><td>0-5</td><td colspan="2">12; NR</td><td>NR</td><td>5.6%</td><td>95.9%</td></tr>
<tr><td colspan="6">- Main reasons for failure were endodontic/periodontic related (35%), veneering material fractures (23%), and loss of retention (19%).
- Main complications were loss of retention (21%), endodontic treatment (18%), veneering material fractures (14%), and periodontal bleeding on probing (12%).
NR = not reported</td></tr>
<tr><td colspan="7">Wang et al. 2012[8] Systematic review – China. Study objective was to evaluate the clinical fracture incidence of tooth-supported all-ceramic crowns according to restored tooth type</td></tr>
<tr><td rowspan="2">Fracture mode</td><td colspan="3">Annual (5-year) fracture incidence</td><td rowspan="2">Difference anterior vs. posterior</td><td rowspan="4">Authors reported that the available evidence suggested that dental ceramic had acceptable 5-year core and veneer fracture. They reported that higher fracture date was associated with posterior crowns compared to anterior crowns.</td></tr>
<tr><td>Over all</td><td>Anterior</td><td>Posterior</td></tr>
<tr><td>Fracture</td><td>1.6% (7.7%)</td><td>0.9% (4.4%)</td><td>2.1% (10.0%)</td><td rowspan="2">Statistically significant</td></tr>
<tr><td>Core fracture</td><td>1.5% (7.2%)</td><td>0.8% (3.9%)</td><td>2.0% (9.5%)</td></tr>
<tr><td>Veneer fracture</td><td>0.6% (3.0%)</td><td>0.4% (2.0%)</td><td>0.5% (2.5%)</td><td>Not significant</td></tr>
</table>

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

<table>
<tr><th colspan="5">Main Study Findings</th><th>Author's Conclusions</th></tr>
<tr><td colspan="6">Heintze et al. 2010[9] Systematic review – Switzerland. Study objective was to evaluate the clinical fracture rate of crowns fabricated with the pressable, leucite-reinforced ceramic IPS Empress according to restored tooth type</td></tr>
<tr><td colspan="4">Hazard ratio of fracture per 1000 crown each year[a]</td><td>Effect of tooth type</td><td rowspan="3">Due to the higher number of fractures on molar teeth, authors concluded that caution should be exercised when used IPS Empress crowns on molars teeth.</td></tr>
<tr><td>Incisors</td><td>Canines</td><td>Premolars</td><td>Molars</td><td rowspan="2">Statistically significant</td></tr>
<tr><td>5</td><td>12</td><td>7</td><td>16</td></tr>
<tr><td colspan="5">[a] the follow-up duration was not reported.</td></tr>
<tr><td colspan="6">Kassem et al. 2010[10] Systematic review – Egypt. Study objective was to evaluate the clinical performance of porcelain molar crowns.</td></tr>
<tr><td></td><td colspan="3">Failure rate at ≥ 5 years, n/N (%)</td><td>Difference between materials</td><td rowspan="2">The authors reported that the overall failure rate of all-ceramic crowns on molars was 10.2% over five years or more.</td></tr>
<tr><td>Type of tooth</td><td>Procera AllCeram (5 studies)</td><td>In-Ceram Alumina/Spinell (one study)</td><td>CEREC (one study)</td></tr>
<tr><td>Molars</td><td>24/235 (10.2%)</td><td>2/37 (5.4%)</td><td>NR (5.4% to 12.9%)</td><td>Not reported</td></tr>
<tr><td colspan="6">Wittneben et al. 2009[11] Systematic review – USA. Study objective was to evaluate the long-term clinical survival rates of single-tooth restorations manufactured with computer-aided design/computer assisted manufacturing (CAD/CAM) technology</td></tr>
<tr><td></td><td>Number of restorations</td><td>Mean exposure time (years)</td><td>Failure rate (per 100 restoration years); (95% CI)</td><td>Survival rate after 5 years; (95% CI)</td><td rowspan="3">The authors reported that the long-term survival rates for CAD/CAM-fabricated single-tooth restorations had clinically similar outcomes to conventionally manufactured restorations.</td></tr>
<tr><td>Crowns</td><td>106</td><td>4.4</td><td>1.6 (0.4, 6.6)</td><td>92.3 (72, 98)</td></tr>
<tr><td colspan="5">CI = confidence interval</td></tr>
<tr><td colspan="6">Wassermann et al. 2006[12] Systematic review – Germany. Study objective was to evaluate the clinical performance of VITA In-Ceramic Alumina, Spinell, and Zirconia restorations</td></tr>
<tr><td></td><td>Number of teeth</td><td>Mean observation time</td><td>Survival rate[a]</td><td>Cumulative survival rate[a]</td><td rowspan="4">The authors concluded that a randomized-controlled trial with follow-up of 5 years or more is needed to evaluate the clinical performance of VITA In-Ceram crowns.</td></tr>
<tr><td>VITA In-Ceram Spinell crowns[a]</td><td>18 to 40</td><td>3 years</td><td>94.5% to 100%</td><td>91.7%[c] to 100%[c]</td></tr>
<tr><td>VITA In-Ceram Alumina crowns[d]</td><td>24 to 546</td><td>2 to 3.5 years</td><td>86.5% to 100%</td><td>92%[c] to 100%[d]</td></tr>
<tr><td colspan="5">[a] survival range based on the lowest and greatest rates reported in the included studies; the authors did not pool survival rates.
[b] four studies [c] after five years [d] at four years</td></tr>
<tr><td colspan="6">El-Mowafy et al. 2002[13] Systematic review – Canada. Study objective was to evaluate the longevity and clinical performance of IPS-Empress restorations.</td></tr>
<tr><td></td><td>Number failures/ crowns</td><td>Mean follow-up (months)</td><td>Survival rate</td><td>Cause of failure</td><td rowspan="2">The authors concluded that IPS-Empress crowns are not suitable for posterior teeth until the results of a sufficient long-term evidence proved otherwise.</td></tr>
<tr><td>IPS-Empress crowns in three studies</td><td>7/75, 1/75, and 5/144</td><td>6 to 68</td><td>95% at 3 years to 92% at 3.5 years</td><td>Fractures:
2 incisors,
3 premolars
6 molars</td></tr>
</table>

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

<table>
<tr><th colspan="6">Main Study Findings</th><th>Author's Conclusions</th></tr>
<tr><td colspan="7">Ho et al. 2012[14] Systematic review – Canada. Study objective was to evaluate the clinical fracture resistance of CAD/CAM composite-based crowns compared to CAD/CAM all-ceramic crowns.</td></tr>
<tr><td></td><td>Number failures/ crowns</td><td>Mean follow-up</td><td>Survival rate</td><td>Cause of failure</td><td colspan="2" rowspan="3">The authors concluded that there was insufficient evidence to recommend the CAD/CAM composite-based crowns.</td></tr>
<tr><td>Composite-resin crowns</td><td>4/59</td><td rowspan="2">3 years</td><td rowspan="2">Not reported</td><td rowspan="2">Not reported</td></tr>
<tr><td>All-ceramic crowns</td><td>3/141</td></tr>
<tr><td colspan="7">Alwash et al. 2010[15] Systematic review – Canada. Study objective was to assess the clinical efficacy of single zirconium-based crowns on posterior teeth</td></tr>
<tr><td></td><td>Number of crowns</td><td>Follow-up</td><td>Success rate[a]</td><td>Marginal integrity</td><td colspan="2" rowspan="6">The authors concluded that long-term studies comparing zirconium crown with porcelain-fused to metal crowns are needed to be conducted before any recommendation can be given on the efficacy of zirconium crowns in the posterior region.</td></tr>
<tr><td>In-Ceram zirconia</td><td>15</td><td>One year</td><td>93.3%</td><td>73% were excellent</td></tr>
<tr><td>Cercon zirconia</td><td>15</td><td>One year</td><td>93.3%</td><td>80% were excellent</td></tr>
<tr><td>Everest HPC</td><td>123</td><td>Two years</td><td>90.5%</td><td>50.5% had perfect marginal fit[b]</td></tr>
<tr><td>Gold crowns</td><td>101</td><td>Two years</td><td>92.7%</td><td>76.5% had perfect marginal fit[b]</td></tr>
<tr><td>Nobel Procera Crowns</td><td>168</td><td>Three years</td><td>92.7%</td><td>80% were excellent, 20% were acceptable</td></tr>
<tr><td colspan="6">[a] The reasons for failure were insufficient ceramic thickness, veneer fracture, history of occlusal adjustments and tooth elongation after loss of provision crown. In one case restoration failed because of the post-core restoration causing root fracture
[b] after one year</td></tr>
<tr><td colspan="7">Rammelsberg et al. 2005,[16] Randomized controlled trial – Germany. The objective of this study was to evaluate the influence of location and preparation design on the survival and complication rate of metal-free polymer crowns</td></tr>
<tr><td>Location of teeth/ type of finishing line</td><td>Number of crowns</td><td>Follow-up</td><td>Number of failures</td><td>Survival rate</td><td>Difference between groups</td><td rowspan="6">The authors concluded that metal free polymer crowns had an acceptable short-term
survival rate</td></tr>
<tr><td>Anterior/ chamfer</td><td rowspan="4">Not reported</td><td rowspan="5">3 years</td><td rowspan="4">Not reported</td><td rowspan="4">Not reported</td><td rowspan="4">Not statistically significant</td></tr>
<tr><td>Posterior/ chamfer</td></tr>
<tr><td>Anterior/ shoulder</td></tr>
<tr><td>Posterior/ shoulder</td></tr>
<tr><td>Overall</td><td>117</td><td>10</td><td>96%</td><td>Not applicable</td></tr>
</table>

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

<table>
<tr><th colspan="5">Main Study Findings</th><th>Author's Conclusions</th></tr>
<tr><td colspan="6">Toman et al.[17] Prospective uncontrolled study. Study objective was to evaluate the clinical performance of lithium disilicate crowns</td></tr>
<tr><td>Tooth location/Status</td><td colspan="2">Number of teeth</td><td>Number of failures</td><td>Survival rate at 9 years (%)</td><td rowspan="5">The authors concluded that location of the all-ceramic crowns did not significantly affect the survival rate. Crown survival on endodontically treated teeth without post-and-core restorations exhibited lower survival.</td></tr>
<tr><td>Anterior teeth</td><td colspan="2">98</td><td>8</td><td>87.4%</td></tr>
<tr><td>Posterior teeth</td><td colspan="2">23</td><td>2</td><td>85%</td></tr>
<tr><td>Vital teeth</td><td colspan="2">110</td><td rowspan="2">Not reported</td><td>91.3%</td></tr>
<tr><td>Endodontically treated teeth</td><td colspan="2">11</td><td>53.0%</td></tr>
<tr><td colspan="6">Tartaglia et al.[18] Prospective uncontrolled study – Italy. Study objective was to the clinical performance of zirconia-based prosthesis</td></tr>
<tr><td colspan="2">Tooth location</td><td>Number of crowns</td><td>Number of failures</td><td>Survival rate at 7 years (%)</td><td>Authors concluded that zirconia core crowns were a good clinical solution for full coverage prosthetics</td></tr>
<tr><td colspan="2">Anterior teeth</td><td>26</td><td rowspan="3">Not reported[a]</td><td rowspan="3">Not reported</td></tr>
<tr><td colspan="2">Posterior teeth</td><td>104</td></tr>
<tr><td colspan="2">Total</td><td>132</td></tr>
<tr><td colspan="6">[a] authors reported 0.07% incidence rate of failure that included crowns supported on implants and natural teeth</td></tr>
<tr><td colspan="6">Galindo et al.[19] 2011 Prospective uncontrolled study – Switzerland. Study objective was to estimate long-term survival of alumina crowns in anterior and posterior areas over an observation period of up to 10 years.</td></tr>
<tr><td colspan="2">Type of failure</td><td>Number of crowns</td><td>Number of failed crowns</td><td>Cumulative survival rate after 9 years (%)</td><td>The authors concluded that alumina crowns had comparable long-term survival rates as metal-ceramic crowns.</td></tr>
<tr><td colspan="2">All failures</td><td>112</td><td>11</td><td>83.9%</td></tr>
<tr><td colspan="2">Technical failures</td><td>112</td><td>3</td><td>95.3%</td></tr>
<tr><td colspan="6">Reich et al.[20] 2010 Prospective uncontrolled study - Germany. Study objective was to evaluate the clinical performance of chairside-generated crowns.</td></tr>
<tr><td colspan="2">Observation period</td><td>Number of crowns</td><td>Number of failed crowns</td><td>Cumulative survival rate (%)</td><td>The authors concluded that chairside-manufactured crowns appeared to have comparable survival rate as metal-ceramic crowns</td></tr>
<tr><td colspan="2">24 months</td><td>39</td><td>1</td><td>97.4%</td></tr>
<tr><td colspan="6">Mansour et a.[21] 2008 Prospective uncontrolled study – Jordan. Study objective was to evaluate the clinical performance of IPS-Empress 2 all-ceramic crowns.</td></tr>
<tr><td>Tooth location</td><td>Number of crowns</td><td>Number of failed crowns</td><td>Median survival time (months)</td><td>Survival rate (%)</td><td>The authors concluded that IPS-Empress 2 was a suitable material for all-ceramic crowns</td></tr>
<tr><td>Anterior teeth</td><td rowspan="2">82</td><td>Not reported</td><td>34.1</td><td rowspan="2">93.9%</td></tr>
<tr><td>Posterior teeth</td><td>Not reported</td><td>23.7</td></tr>
<tr><td colspan="6">Valenti 2015,[22] Retrospective uncontrolled study. Study objective was the clinical performance of lithium disilicate crowns with a feather-edge finish line over a 9-year period</td></tr>
<tr><td colspan="2">Tooth location</td><td>Number of teeth</td><td>Number of failures</td><td>Survival rate (at 9 years)</td><td>The author concluded that the survival rate reported in this study for lithium disilicate crown was similar to survival rates reported for other all-ceramic materials.</td></tr>
<tr><td colspan="2">Anterior teeth</td><td>39</td><td>0</td><td>100%</td></tr>
<tr><td colspan="2">Posterior teeth</td><td>71</td><td>2</td><td>94.5%</td></tr>
<tr><td colspan="2">Total</td><td>110</td><td>2</td><td>96.1%</td></tr>
</table>

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

Main Study Findings				Author's Conclusions
Guncu et al.[23] Retrospective uncontrolled study. Study objective was to evaluate the 5-year clinical performance of zirconia-based crowns				
Tooth location	**Number of teeth**	**Number of failures**	**Survival rate at 5 years (%)**	The authors concluded that zirconia-based crowns were an acceptable treatment option for the replacement of anterior and posterior teeth.
Maxilla				
Central incisors	75	0	100.0	
Lateral incisors	64	0	100.0	
Canines	55	0	100.0	
First premolars	65	1	98.5	
Second premolar	66	0	100.0	
First molar	60	4	93.3	
Second molar	28	3	89.3	
Mandible				
Central incisors	23	1	95.7	
Lateral incisors	22	0	100.0	
Canines	20	1	95.0	
First premolars	27	0	100.0	
Second premolar	38	0	100.0	
First molar	51	0	100.0	
Second molar	24	2	91.7	
Overall	618	12	98.1	

Gherlone et al.[24] 2014 Retrospective uncontrolled study – Italy. The study objective was to evaluate the clinical performance of glass-ceramic/zirconia crowns fabricated using intraoral digital impressions					
Observation period	**Number of crowns**	**Number of failures**	**Chipping rate**	**Success rate (%)**	The authors concluded that fatigue-mechanism might be responsible of increased failures after 24 months of function
12 months	86	8	9.3%	90.7%	
24 months		4	14%	86.0%	
36 months		14	30.2%	69.8%	

Fabbro et al.[25] 2014 Retrospective uncontrolled study – Italy. The study objective was to evaluate the clinical performance of lithium disilicate restorations					
	Number of crowns	**Mean follow-up**	**Cumulative survival rate (%)**	**Cumulative success rate (%)**	The authors concluded that lithium disilicate crowns to be effective materials on short and medium term.
Anterior veneered	209	37.3	98.6%	97.6%	
Anterior monolithic	22	33.4	95.5%	95.5%	
Posterior veneered	65	28.3	96.9%	95.4%	
Posterior monolithic	132	42.1	96.2%	96.2%	
Total	428		98.6%	97.6%	

Dhima et al.[26] 2014 Retrospective uncontrolled study – USA. Study objective was to evaluate the clinical performance of ceramic single crowns			
Number of crowns	**Mean follow-up**	**Cumulative survival rate (%)**	The authors concluded that further data were required to compare monolithic ceramic systems and layered systems for posterior teeth application
226	1 year	99.1%	
	3 years	95.1%	
	5 years	92.8%	
	10 years	92.8%	

Table 12: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns				
Main Study Findings				**Author's Conclusions**
Vavrickova et al.[27] 2013 Retrospective uncontrolled study – Czech Republic. Study objectives was to evaluate the clinical outcomes of all-ceramic crowns three years after placement				
Tooth vitality status	**Number of crowns**	**Mean follow-up**	**Cumulative survival rate (%)**	The authors concluded that all-ceramic crowns with polycrystalline ceramic cores have low susceptibility to fracture in medium term, but long-term longevity was unknown.
Vital	102	Up to three years	Not reported	
Endodontically treated	19			
Overall	121		96.7%	

Table 13: Summary of Findings - Longevity of All-ceramic/Porcelain Crowns

<table>
<tr><th colspan="5">Main Study Findings</th><th>Author's Conclusions</th></tr>
<tr><td colspan="6">Behr et al. 2014,[29] Retrospective observational study. The study objective was evaluate the frequency and time to chipping and facing failures, recurrent caries, periodontitis and loss of retention of porcelain fused to metal crowns</td></tr>
<tr><td rowspan="2">Survival period</td><td rowspan="2">Number of crowns</td><td>Survival rate</td><td>Chipping and facing free rates</td><td>Recurrent caries/periodontitis</td><td rowspan="4">The authors concluded that porcelain-fused to metal crowns had long-term survival.</td></tr>
<tr><td colspan="3">Anterior teeth / Posterior teeth</td></tr>
<tr><td>5 years</td><td rowspan="2">997 crowns</td><td>96.4% / 97.5%</td><td>98.9%/ 98.2%</td><td>98.7%</td></tr>
<tr><td>10 years</td><td>92.3% / 95.9%</td><td>97.3%</td><td>97.2%</td></tr>
<tr><td colspan="6">Hey et al. 2014,[30] Prospective observational study. The study objective was to evaluate Computer-aided design/computer-aided manufacturing (CAD/CAM) titanium ceramic single crowns after 6 years in function</td></tr>
<tr><td></td><td>Number of crowns</td><td>Mechanical complications</td><td>Cumulative survival at 6 years</td><td>Difference based on tooth location</td><td rowspan="4">The authors concluded that survival of the CAD/CAM titanium-ceramic crowns with a non-anatomic coping design was poor.</td></tr>
<tr><td>Anterior teeth</td><td>12</td><td>1</td><td rowspan="2">Not reported</td><td rowspan="3">Not reported</td></tr>
<tr><td>Posterior teeth</td><td>29</td><td>11</td></tr>
<tr><td>Total</td><td>41</td><td>12</td><td>67.8%</td></tr>
</table>

Table 14: Summary of Findings - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns

Main Study Findings					Author's Conclusions
Sailer et al. 2015[2] Systematic review – Switzerland. Study objective was to evaluate the 5-year survival of metal-ceramic and all-ceramic tooth-supported single crowns (SCs)					
Type of crowns	**Follow-up (years) / Total crowns / Total crown exposure time**	**5-year survival rate (95% CI)**	**Relative failure rate; P-value**	**Difference between anterior and posterior crowns**	The authors concluded that all-ceramic crowns have similar survial rates as metal-ceramic crowns after 3-years of observation. They emphasized that all-ceramic crowns made from densely sintered zirconia could not be recommended for use due to an increased risk of chipping of the veneering ceramic and loss of retention. They also concluded that feldspathic or silica glass-ceramics can only be recommended in anterior regions with low functional load.
Metal ceramic	4663/ 7.3/ 33,965	96% (94%, 97%)	1.00 (reference)	No difference	
Feldspathic/silica-based ceramic	2208/ 7.1/ 15,710	90.7% (88%, 93%)	2.23 (1.45, 3.45); P<0.001	Anterior crowns have longer survival	
Leucit or lithium-disilicate reinforced glass ceramic	2689/ 4.5/ 12,231	96.6% (95%, 98%)	0.79 (0.47, 1.32); P = 0.373	No difference	
Glass-infiltrated ceramic	2389/ 4.9/ 11,644	94.6% (93%, 96%)	1.27 (0.82, 1.96); P= 0.276		
Densely sintered alumina	1099/ 4.3/ 4829	96% (94%, 98%)	0.92 (0.54, 1.57); P= 0.761		
Densely sintered zirconia	1049/ 3.7/ 3918	92% (83%, 96%)	2.09 (0.99, 4.45); P = 0.055	Anterior crowns have longer survival	
Composite crowns	59/ 2.8/ 165	83.4% (68%, 94%)	4.14 (3.01, 5.70); P < 0.001	Not reported	
Takeichi et al. 2013[31] Systematic review – USA. Study objective was to evaluate the clinical survival rates of Zirconia all-ceramic single crowns on anterior and posterior teeth and to compare them with metal ceramic crowns					
Type of crowns	**Follow-up (months) / Total crowns / Total crown exposure time**	**Survival 3-year rate %**			The authors concluded that there were limited data to compare crowns made from porcelain fused to zirconia with those made from metal ceramic. They also reported that survival rates might be affected by the veneering ceramic, and long-term data were needed to obtained definitive conclusions.
		Anterior	**Posterior**	**Total**	
All-ceramic	24 to 39/ 300/ not reported	100%	95.5%	95.9%	
Metal-ceramic	12 to 298/ 3321/ not reported	95.2%	95.7%	95.4%	
Difference between the two types	Not reported				
Ohlmann et al. 2014,[32] Randomized controlled trial – Germany. The objective of the study was to evaluate and compare the clinical performance of posterior, metal-free polymer and metal–ceramic crowns.					
Type of crowns	**Number of crowns**	**Number of failures**	**Observation time**	**Hazard ratio (95% CI)**	The authors concluded that the clinical performance of polymer crowns with or without fibre framework were not significantly different
Polymer crowns with glass-fiber framework	40	10	48 to 72 months (median 30 months)	Reference	

Table 14: Summary of Findings - Longevity of Porcelain-fused-to-Metal Crowns Compared with All-ceramic Crowns					
Main Study Findings					**Author's Conclusions**
Polymer crowns without framework	40	12		1.16 (0.50 to 2.70)	from that of metal–ceramic crowns, although the number of catastrophic failures of composite crowns were higher compared with that of metal–ceramic crowns.
Metal-ceramic	40	8		0.74 (0.29 to 1.87)	
Burke et al. 2009,[33] Controlled observational study – UK. The study objective was evaluate the factors associated with the need for re-intervention on a crown, and the times to re-intervention					
Observation time	**Crown type**			**Difference between crowns**	The authors concluded that metal crowns were found to have the longest survival at 10 years, and all-porcelain crowns the shortest. However, it should be noted that the analysis included crowns made up to 2002. Therefore, newer ceramic materials were not included in the evaluation.
	All-metal crowns	**Metal-ceramic crowns**	**All-ceramic crowns**		
1 year	94%	93%	92%	Not reported	
5 years	80%	76%	68%		
10 years	68%	62%	48%		

Table 15: Summary of Findings of the Cost-effectiveness Study

Main Study Findings					Author's Conclusions
Kelly et al, 2004[34] – Australia					
Survival and cost-effectiveness estimates, by crown type					The anterior ceramo-metal crowns were more cost effective than porcelain jacket crowns over the longer term.
		PFM crown	**Porcelain Jacket crown**	**Class I amalgam**	
Number of restorations		212	18	269	
Percentage survival	5-year	93.3%	94.1%	91.3%	
	10-year	88.2%	66.6%	85.8%	
	15-year	76.9%	66.6%	82.5	
Discounted costs (A$)	1992	695	606.4	50.0	
Incremental cost effectiveness ratio (relative to Class I amalgam)[b]	5-year	245.1	173.4	Reference	
	10-year	160.3	-19.1[a]	Reference	
	15-year	-49.6[a]	-17.0[a]	Reference	
[a] negative value denotes that the restoration survival was less than the Class I amalgam [b] lower values mean higher benefits					

APPENDIX 5: LIST OF PRIMARY STUDIES IN THE INCLUDED SYSTEMATIC REVIEWS

Pieger et al. 2014[6] – USA. Study objective was to analyze the short-term (1- to 5-year) and medium-term (5- to 10-year) survival rates of lithium disilicate single crowns and partial fixed dental prostheses.

- Seven studies reported results of single crowns
  - Reich and Schierz (2013)
  - Esquivel-Upshaw et al. (2013)
  - Cortellini and Canale (2012)
  - Fasbinder et al (2010)
  - Etman and Woolford (2010)
  - Valenti and Valenti (2009)
  - Suputtamongkol et al. (2008)
  - Taskonak and Sertgöz (2006)

Larsson et al. 2014[7] – Sweden. Study objective was to evaluate the documented clinical success of zirconia-based crowns in clinical trials.

- Sixteen studies reported results of single crowns on natural teeth
  - Beuer et al. 2010
  - Cehreli et al. 2009
  - Groten and Hutting 2010
  - Keough et al. 2011
  - Kollar et al. 2008
  - Poggio et al. 2012
  - Rinke et al. 2011
  - Sagirkaya et al. 2010
  - Schmitt et al. 2010
  - Silva et al. 2011
  - Tartaglia et al. 2011
  - Ortrop et al. 2012

Wang et al. 2012[8] – China. Study objective was to evaluate the clinical fracture incidence of tooth-supported all-ceramic crowns according to restored tooth type

- 37 studies reported results of single crowns on natural teeth
  - Etman and Woolford 2010
  - Sorrentino et al. 2009
  - Kokubo et al. 2009
  - Zitzmann et al. 2007
  - Walter et al. 2006
  - Zarone et al. 2005
  - Odman et al. 2001
  - Oden et al. 1998
  - Cehreli et al. 2011
  - Kkubo et al. 2010
  - Bindl and Mormann 2002
  - Scherrer et al. 2001
  - Haselton et al. 2000
  - Probster 1996
  - Scotti et al. 1995
  - Bindl and Mormann 2004
  - Fradeani et al. 2002
  - Mao et al. 2008
  - Chen and Zhang 2007
  - Burke 2007
  - Chen et al. 2006
  - Bindl et al. 2005
  - Erpenstein et al. 2000
  - Malament and Socransky 1999
  - Sjogren et al. 1999
  - Kelsey et al. 1995
  - Valenti and Valenti 2009
  - Toksavui abd Toman 2007
  - Marquardt and Strub 2006
  - Malament et al. 2003
  - Fradeani and Redemagni 2002
  - Sorensen et al. 1998
  - Studer et al. 1998
  - Fradeani and Aquilano 1997
  - Barnes et al. 2010
  - Schmitt et al. 2010
  - Ortorp et al. 2009

Heintze et al. 2010[9] – Switzerland. Study objective was to evaluate the clinical fracture rate of crowns fabricated with the pressable, leucite-reinforced ceramic IPS Empress according to restored tooth type
• Seven studies reported results of single crowns on natural teeth ○ Fradeani and Redemagni 2002 ○ Studer et al. 1998 ○ Malament et al. 2003 ○ Sjogren et al. 1998 ○ Gemalmaz and Ergin 2002 ○ Edelhoff et al. 2000 ○ Sorensen et al. 1998
Kassem et al. 2010[10] – Egypt. Study objective was to evaluate the clinical performance of porcelain molar crowns.
• Eight studies reported results of single crowns on natural teeth ○ Fradeani et al. 2005 ○ Odman and Andersson 2001 ○ Naert et al. 2005 ○ Bindl and Mormann 2002 ○ Zitzmann et al. 2007 ○ Oden et al. 1998 ○ Bindl et al. 2005 ○ Walter et al. 2006
Wittneben et al. 2009[11] – USA. Study objective was to evaluate the long-term clinical survival rates of single-tooth restorations manufactured with computer-aided design/computer assisted manufacturing (CAD/CAM) technology
• 5.4% of all studies reported results of single full crowns (the exact studies reporting these results were not specified) ○ Isenberg et all. 1992 ○ Heymann et al. 1996 ○ Bindl and Mormann 2002 ○ Thordrup et al. 30 ○ Molin and Karlsson 20 ○ Pallesen and van Dijken 2000 ○ Reiss and Walther 2000 ○ Bindl and Mormann 2002 ○ Mormann and Krejci 1992 ○ Bindl and Mormann 2004 ○ Reich et al. 2004 ○ Sjogren et al. 2004 ○ Bindl et al. 2005 ○ Fasbinder et al. 2005 ○ Thordrup et al. 2006 ○ Otto and De Nisco 2002
Wassermann et al. 2006[12] – Germany. Study objective was to evaluate the clinical performance of VITA In-Ceramic Alumina, Spinell, and Zirconia restorations.
• Eleven studies reported results of single crowns ○ Bindl and mormann 2002 ○ Fradeani et al. 2002 ○ Groten et al. 2002 ○ Bindl and Mormann 2004 ○ Sorensen et al. 1992 ○ Pang 1995 ○ Sorensen et al. 1998 ○ Vult von Steyern et al. 2001 ○ Olsson et al. 2003 ○ Probster 1993
El-Mowafy et al. 2002[13] – Canada. Study objective was to evaluate the longevity and clinical performance of IPS-Empress restorations
• Three studies reported results of single crowns ○ Sorensen et al. 1998 ○ Fradeani and Aquilano 1997 ○ Sjogren et al. 1999
Ho et al. 2012[14] – Canada. Study objective was to evaluate the clinical fracture resistance of CAD/CAM composite-based crowns compared to CAD/CAM all-ceramic crowns.
• Vanoorbeek et al. 2010

Alwash et al. 2010[15] – Canada. Study objective was to evaluate the efficacy of posterior zirconium crown compared with porcelain-fused to metal crowns

- Three studies reported results of single crowns
  - Cehreli et al. 2009
  - Encke et al. 2008
  - Ortrop et al. 2009

Sailer et al. 2015[2] – Switzerland. Study objective was to evaluate the 5-year survival of metal-ceramic and all-ceramic tooth-supported single crowns (SCs)

- Sixty two studies reported results of single crowns
  - Gehrt et al. 2013
  - Passia et al. 2013
  - Reitemeier et al. 2013, 2005
  - Sagitkaya et al. 2012
  - Ortorp et al. 2012
  - Wolleb et al. 2012
  - Beier et al. 2012
  - Cehreli et al. 2011
  - Abou Tara et al. 2011
  - Beuer et al. 2010
  - Vanoorbeek et al. 2010
  - Boeckler et al. 2009
  - Valenti & Valenti 2009
  - Toksavul & Toman 2007
  - Gungor et al. 2007
  - De Backer et al. 2007
  - Malament et al. 2001 and 2006
  - Naert et al. 2005
  - Marquardt & Strub 2006
  - Marklund et al. 2003
  - Fradeani & Redemagni 2002
  - Fradeani et al. 2002
  - Scherrer et al. 2001
  - Ödmann et al. 2001
  - Haselton et al. 2000
  - Erpenstein et al. 2000
  - Sjögren et al. 1999
  - Sorensen et al. 1998
  - Pröbster 1997
  - Hüls 1995
  - Bieniek 1992
  - Monaco et al. 2013
  - Rinke et al. 2013
  - Walton 2013
  - Sorrentino et al. 2012
  - Vigolo & Mutinelli 2012
  - Cortellini & Canale 2012
  - Rinke et al. 2011
  - Kokubo et al. 2011
  - Naumannet al. 2011
  - Schmitt et al. 2010
  - Kokubo et al. 2009
  - Signore et al. 2009
  - Napankangas et al. 2008
  - Burke 2007
  - Eliasson et al. 2007
  - Brägger et al. 2007
  - Galindo et al. 2006
  - Walter el al. 2005
  - Bindl & Mörmann 2004
  - Bindl & Mörmann 2002
  - van Dijken et al. 2001
  - Segal 2001
  - McLaren & White 2000
  - Edelhoff et al. 2000
  - Sjögren et al. 1999
  - Oden et al. 1998
  - Studer et al. 1998
  - Jokstad & Mjör 1996
  - Scotti et al. 1995
  - Kelsey et al. 1995
  - Cheung et al. 1991

Takeichi et al. 2013[31] – USA. Study objective was to evaluate the clinical survival rates of Zirconia all-ceramic single crowns on anterior and posterior teeth and to compare them with metal ceramic crowns

- Nineteen studies were included
  - Cehreli et al. 2009
  - Beuer et al. 2010
  - Cheung et al. 1991
  - Nilson et al. 1994
  - Martin et al. 1997
  - Walton et al. 1999
  - Marklund et al. 2003
  - Reitemeier et al. 2006
  - Napankangas et al. 2008
  - Ortrop et al. 2009
  - Schmitt et al. 2010
  - Palmqvist et al. 1993
  - Kaus et al. 1996
  - Smales et al. 1997
  - Lovgren et al. 2000
  - Backer et al. 2006
  - Eliasson et al. 2007
  - Boeckler at al. 2009
  - Abou tara et al. 2011